PB-238 764

CHEMICAL IMPACT OF SNOW DUMPING PRACTICES

Philip J. O'Brien, et al

Arthur D. Little, Incorporated

Prepared for:

National Environmental Research Center

December 1974

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. PB 238 764
EPA-670/2-74-086		

4. TITLE AND SUBTITLE	5. REPORT DATE
Chemical Impact of Snow Dumping Practices	December 1974; Issuing Date
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Philip J. O'Brien, Philip L. Levins, Clifford H. Summers	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Arthur D. Little, Inc. Acorn Park Cambridge, Massachusetts 02140	1BB034/ROAP 21ATB/Task 036
	11. CONTRACT/GRANT NO. XXXXXXX 68-03-0154
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
National Environmental Research Center Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268	Final - 7/72 to 6/74
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report contains the results of a study conducted for the U.S. Environmental Protection Agency to evaluate the chemical effects of dumping of snow collected from the municipal streets into watercourses or waterbodies in three selected areas: a large river (Mohawk at Schenectady,N.Y.),a smaller river (Concord at Lowell, Mass.),and a small pond (Horn at Woburn, Mass.).

Unusually low snowfall during the winters of 1972-73 and 1973-74 together with a nationwide gasoline shortage (which limited or curtailed snow dumping operations) resulted in insufficient data. The following conclusions are, therefore, based on limited observations and tests:

1. Little effect of snow dumping was observed in the downstream concentration of any species examined.
2. Increased chemical concentrations observed during the late summer low-flow period were as great as any effect related to salt use examined in this study.
3. The maximum possible increase in concentration of chloride was calculated to be no more than 0.04 mg/l in the waterbody of lowest dilution volume (Horn Pond). This concentration is less than the precision of the assay technique used.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Calcium chlorides Deicers *Ice Water supply *Snow Snow removal Snowmelt *Runoff	*Salt Highway deicing chemicals Snow management *Water quality control Surface groundwater relationship	13B 13M

PRICES SUBJECT TO CHANGE

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release to Public	Unclassified	48
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	3.75

EPA Form 2220-1 (9-73)

Reproduced by
NATIONAL TECHNICAL INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

028111

EPA-670/2-74-086
December 1974

CHEMICAL IMPACT
OF
SNOW DUMPING PRACTICES

By

Philip J. O'Brien
Project Director

Philip L. Levins
Clifford H. Summers

Arthur D. Little, Inc.
Cambridge, Massachusetts 02140

Contract No. 68-03-0154
Program Element No. 1BB034

Project Officer

Hugh E. Masters
Storm and Combined Sewer Section (Edison, N.J.)
Advanced Waste Treatment Research Laboratory
National Environmental Research Center
Cincinnati, Ohio 45268

NATIONAL ENVIRONMENTAL RESEARCH CENTER
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

REVIEW NOTICE

The National Environmental Research Center -- Cincinnati has reviewed this report and approved its publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment -- air, water, and land. The National Environmental Research Centers provide this multi-disciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

The study described here was undertaken to determine the pollutional magnitude of continued practices of removing and dumping quantities of snow from streets and highways into nearby water bodies or onto water supply watersheds.

A.W. Breidenbach, Ph.D.
Director
National Environmental
Research Center, Cincinnati

ABSTRACT

This report contains the results of a study conducted for the U.S. Environmental Protection Agency to evaluate the chemical effects of dumping of snow collected from the municipal streets into watercourses or waterbodies in three selected areas: a large river (Mohawk at Schenectady, N.Y.), a smaller river (Concord at Lowell, Mass.), and a small pond (Horn in Woburn, Mass.).

Unusually low snowfall during the winters of 1972-73 and 1973-74 together with a nationwide gasoline shortage (which limited or curtailed snow dumping operations) resulted in insufficient data. The following conclusions are, therefore, based on limited observations and tests:

1. Little effect of snow dumping was observed in the downstream concentration of any species examined.

2. Increased chemical concentrations observed during the late summer low-flow period were as great as any effect related to salt use examined in this study.

3. The maximum possible increase in concentration of chloride was calculated to be no more than 0.04 mg/l in the waterbody of lowest dilution volume (Horn Pond). This concentration is less than the precision of the assay technique used.

This report was submitted in partial fulfillment of Program Element 1BB034, Contract No. 68-03-0154 by Arthur D. Little, Inc., under the sponsorship of the Environmental Protection Agency. Work was completed in June 1974.

CONTENTS

	Page
Review Notice	ii
Foreword	iii
Abstract	iv
List of Figures	vi
List of Tables	vii
Acknowledgements	viii
CONCLUSIONS	1
SUMMARY AND RECOMMENDATIONS	2
SAMPLING PROGRAM	5
Site Selection	5
CHEMICAL ANALYSES	10
Species Analyzed	10
Samples Base/Methods	12
DATA ANALYSIS	14
REFERENCES	27
APPENDIX A - CHEMICAL ANALYSIS DATA SHEETS	28

FIGURES

No.		Page
1	Location of Representative Snow Dumping Sites	6
2	Sampling Locations - Mohawk River, Schenectady, New York	7
3	Sampling Locations - Concord River, Lowell, Massachusetts	8
4	Sampling Locations - Horn Pond, Woburn, Massachusetts	9
5	Chloride Concentration Levels	16
6	Nitrate Concentration Levels	17
7	Phosphate Concentration Levels	18
8	Chromium Concentration Levels	19
9	Lead Concentration Levels	20
10	Iron Concentration Levels	21
11	Total Solids Concentrations	22
12	Total Dissolved Solids Concentration Levels	23
13	Comparison of Woburn Chloride, Nitrate and Lead Lead Values	24
14	Comparison of Lowell Chloride, Nitrate and Lead Values	25
15	Comparison of Schenectady Chloride, Nitrate and Lead Values	26

TABLES

No.		Page
1	Chemical Species, Analytical Method and Detection Limit	11
2	Sampling Frequency	13
A-1	Summary of Sampling Analysis - Chloride, Cyanide	29
A-2	Summary of Sampling Analysis - Nitrate Nitrogen, Total Phosphorous	30
A-3	Summary of Sampling Analysis - Ammonia Nitrogen, Total Kjeldahl Nitrogen	31
A-4	Summary of Sampling Analysis - Chromium, Cr^{+6}	32
A-5	Summary of Sampling Analysis - Copper, Lead	33
A-6	Summary of Sampling Analysis - Iron, Zinc	34
A-7	Summary of Sampling Analysis - Sodium, Calcium	35
A-8	Summary of Sampling Analysis - Mercury, Nitrite Nitrogen	36
A-9	Summary of Sampling Analysis - Total Solids. Dissolved Solids	37
A-10	Summary of Sampling Analysis - Oil and Grease, COD	38
A-11	Summary of Sampling Analysis - Loss on Ignition	39

ACKNOWLEDGEMENTS

This work was conducted in partial fulfillment of Contract No. 68-03-0154 under the direction of Hugh Masters, Project Officer, and Richard Field of the Storm and Combined Sewer Section, Advanced Waste Treatment Research Laboratory, National Environmental Research Center - Cincinnati, Edison, New Jersey 08817.

Anthony Samsel and Richard Pride of Arthur D. Little, Inc., were responsible for gathering samples, and Celeste Babineau, Jane Morris, and Lawrence Damokosh analyzed them.

CONCLUSIONS

The following conclusions have been reached as a result of a snow sampling and analysis program conducted in New York and Massachusetts during the two winter seasons 1972-73 and 1973-74. The conclusions specifically and exclusively refer to the chemical effects of the dumping of snow collected from municipal streets into watercourses and waterbodies.

- Little effect of snow dumping is observed in the downstream concentration of any of the chemical species analyzed.

- Increased chemical concentrations observed during the late summer low-flow periods are as great as any effect related to salt use as examined in this study.

These conclusions are based on limited observations and tests due to unusual low snowfall during the study period, together with a nationwide gasoline shortage (which limited or curtailed snow dumping operations in the study areas).

SUMMARY AND RECOMMENDATIONS

SUMMARY

The United States annually applies approximately 9 million tons of salt or other deicing chemicals to its highways to improve winter driving conditions. In some locations, these deicing salts have had an adverse effect on roadside vegetation and on surface water and groundwater supplies. Salt enters these systems by one or a combination of three possible pathways:

1. Salt dissolves in the melting snow and runs off directly;

2. Traffic splashes the salt or salt solution onto the roadside environment where it percolates into the soil entering the water table or is deposited on the roadside vegetation;

3. Salt-laden ice and snow is picked up and hauled away for disposal in waterbodies or on land.

Many highway departments dispose of snow in nearby waterbodies (lakes, ponds, rivers, and streams). This practice is most common in urban areas with large snowfalls where the area available for storage of collected snow is limited. Along with the deicing agent, primarily sodium chloride, other substances that become mixed with the snow are suspended solids, organics, phosphates, lead, oil, trash, soot, and soil. All of these substances may have an adverse impact on the ecology of the receiving waterbody.

The effect of snow dumping upon the receiving waterbody is dependent upon a number of variables:

- size of the waterbody (amount of diluting water receiving runoff or snow disposal),
- rate of water flow,
- amount of snow disposed,
- nature of disposal site (ice or open water),
- amount of deicing substance,
- presence of other substances,
- amount of deicing agent from runoff, and
- other sources of pollution.

A study in the State of Washington by Sylvester and Dewalle states that dumping of large quantities of snow and ice containing deicing chemicals and other roadside contaminants into bodies of water may concentrate the adverse effects of highway runoff at the dumping site. Impacts associated with highway runoff and storm sewer inflow and the presence of deicing salts in particular include: a salty taste of water caused by salt; small amounts of toxic cyanides and chromates, which harm aquatic biota and are cause for rejection of public water supply use; and phosphates, which may stimulate undesirable growth of aquatic plants. The Washington State Highway Department does not presently dispose of snow in waterbodies.[1]

Desmaris[2] studied snow disposal in Ottawa, Canada, including the impacts of snow disposal by dumping either on ice or in fast-flowing open water. These two methods of snow disposal have subsequently been abandoned upon recommendations of the Ministry of the Environment of Ontario. In the Ottawa area, snow disposal on ice was in shallow water with a low-velocity flow rate. Chloride from road salt in this snow was not found to be a major concern because it steadily leached out of the dumped snow during the winter and the remaining chloride was greatly diluted when the ice breakup occurred during spring runoff. The principal problem associated with snow disposal on ice is the blanketing effect of the sediment, which is mixed with the snow, on riverbed vegetation. During spring thaw the ice melts and the sediment sinks to the bottom leading to increased concentration of lead in river bottom sediments.

For example, at one point on the Rideau River when snow was dumped on ice, the concentration of lead in sediment was found to be 1,344 mg/kg. The Rideau River has a mean lead concentration in the bottom sediment of 42 mg/kg. In 1972, the lead concentration in the former snow disposal site was 183 mg/kg, a reduction indicating that physical scour was taking place.

In order to determine the impact of the direct disposal of snow into rivers, a controlled experiment was performed on March 3, 1973. About 520 tons of snow per hour were dumped into the Ottawa River from two sites in the City of Ottawa. The samples contained an average of from 2,410 mg/kg to 3,965 mg/kg of salt in the snow. The chloride value upstream in the Ottawa River was 4.2 mg/1. The surface water at the monitoring site downstream yielded a measured chloride content of 3.7 mg/1, with 3 mg/1 measured at 5-, 10-, and 15-foot depths. Monitoring at a site somewhat further downstream for three days (March 3-5) revealed a chloride content of 4.0, 5.0, and 3.0 mg/1, respectively. These data suggest that dumping snow at the test rate of 520 tons per hour had little or no effect on the chloride readings in the Ottawa River, even with snow containing as much salt as 3,965 mg/kg.

The purpose of this study was to examine the impact of direct dumping of salt-contaminated snow into watercourses and waterbodies in the process of municipal snow removal. Specifically, we:

- Identified the areas and specific locations where the snow was being disposed of,

- Determined quantitatively the chemical characteristics of the snow being disposed of in three selected locations, and

- Monitored the depository before and after dumping to determine time-related chemical concentrations during the period from December, 1972 to February, 1974, a period that had unusually low snowfall for the study area and that was affected by a nationwide gasoline shortage which limited or curtailed snow-dumping operations.

RECOMMENDATIONS

Areas that require snow disposal operations must have prearranged plans for dump sites. Material mass balances should be estimated, and every effort should be made to minimize the effect of discharge of waste materials from snow disposal areas into the aquatic environment.

SAMPLING PROGRAM

SITE SELECTION

The three sites selected for sampling and analysis (Figure 1) are located at and near:

Mohawk River - Schenectady, New York;
Concord River - Lowell, Massachusetts; and
Horn Pond - Woburn, Massachusetts.

These sites were selected because they represent a range of conditions; a large river, a relatively slowly flowing river, and a small pond. In addition, the sites were accessible during the winter and within 200 miles of Cambridge, Massachusetts, so that constraints could be met for sample retention time (such as for cyanide, which had to be analyzed within 24 hours of sample collection).

Mohawk River - Schenectady, New York

The City of Schenectady is on the banks of the Mohawk River west of that river's confluence with the Hudson. Contractors haul and dump snow from the downtown shopping area into the Mohawk River (Figure 2). Within the last two years, the New York State Water Resources Commission has reclassified the stretch of the river including the dump area from "B" to "A". The best usage of Class "B" waters is for bathing and any other usages except as a source of water supply for drinking, culinary, or food processing purposes. The best usage of Class "A" waters is as a source of water supply for drinking, culinary, or food processing purposes and any other usage. Downstream from the dump site, the Town of Niskayuna has a groundwater, induced infiltration well-field water supply. As a result, the quality of the river water is of fundamental importance to the quality of the water produced by Niskayuna wells.

Concord River - Lowell, Massachusetts

The Lowell Department of Public Works collects snow and dumps it directly into the Concord River just upstream of that river's confluence with the Merrimack River (Figure 3). Lowell utilizes 25 city trucks, as well as 28 vehicles from private contractors during snow removal operations.

Horn Pond - Woburn, Massachusetts

The Town of Woburn, Massachusetts, is located about 10 miles northwest of Boston in the Mystic River Watershed. Snow cleared from downtown Woburn streets was dumped directly into Horn Pond (Figure 4) when the study was initiated but the practice was subsequently discontinued. From the pond the water flows southeastward via Horn Pond Brook to the Aberjona River and thence into the Mystic Lakes. Chloride levels in the Mystic Lakes have increased significantly in recent years. Samples taken in Horn Pond by Massachusetts Department of Public Health officials show an increase in chlorides from 97 mg/l to 180 mg/l in the period 1970-71.

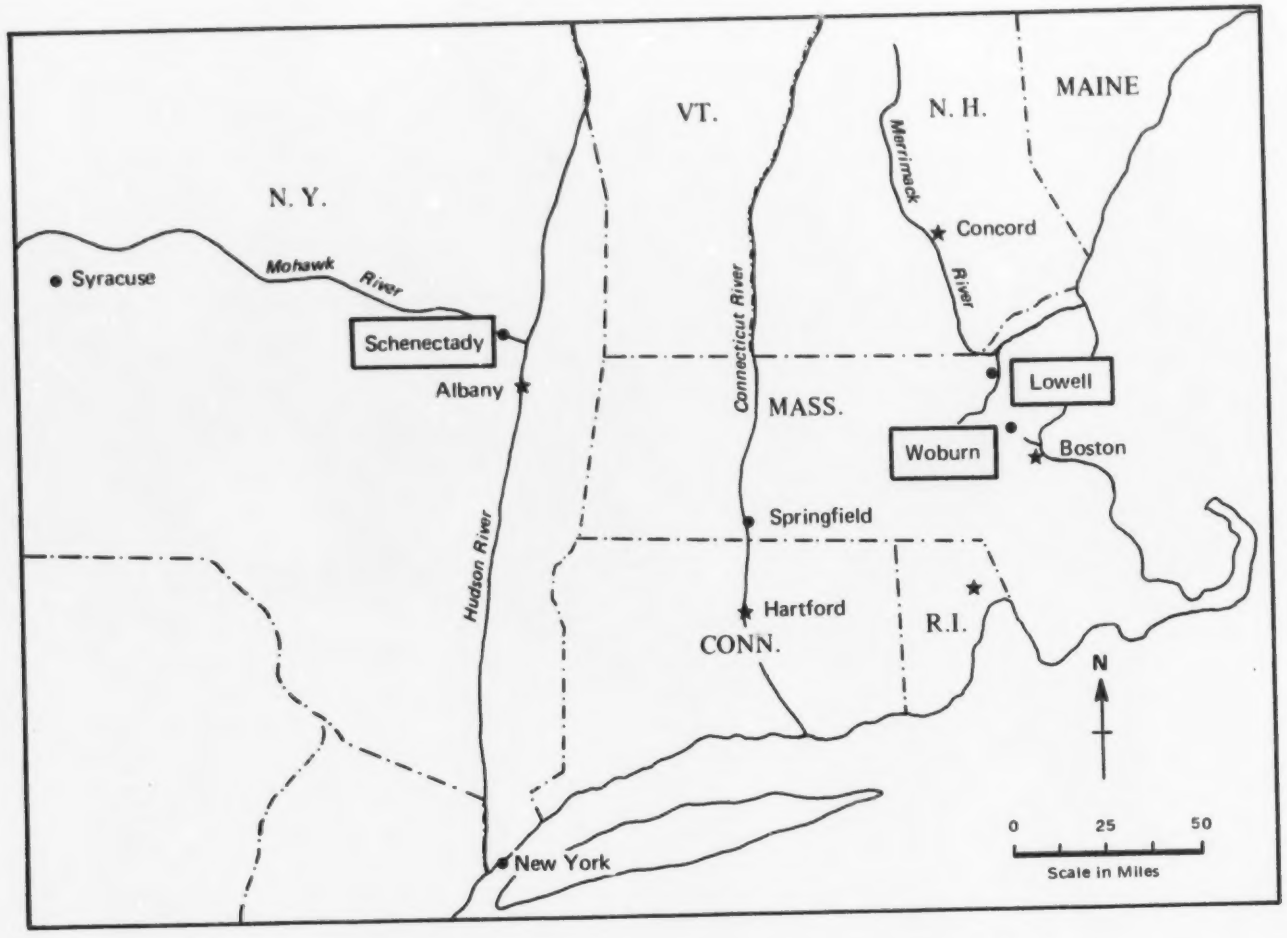


FIGURE 1 LOCATION OF REPRESENTATIVE SNOW DUMPING SITES

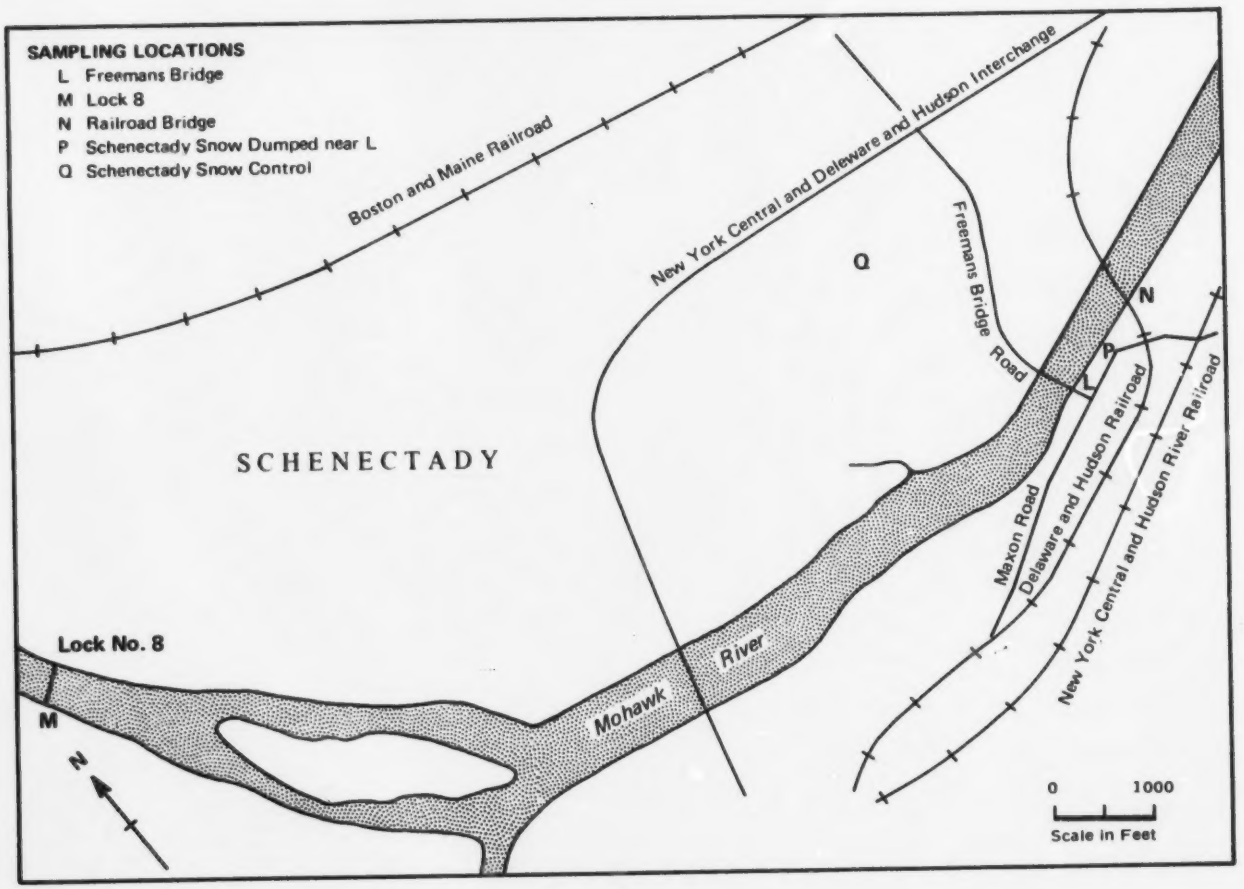


FIGURE 2 SAMPLING LOCATIONS – MOHAWK RIVER, SCHENECTADY, NEW YORK

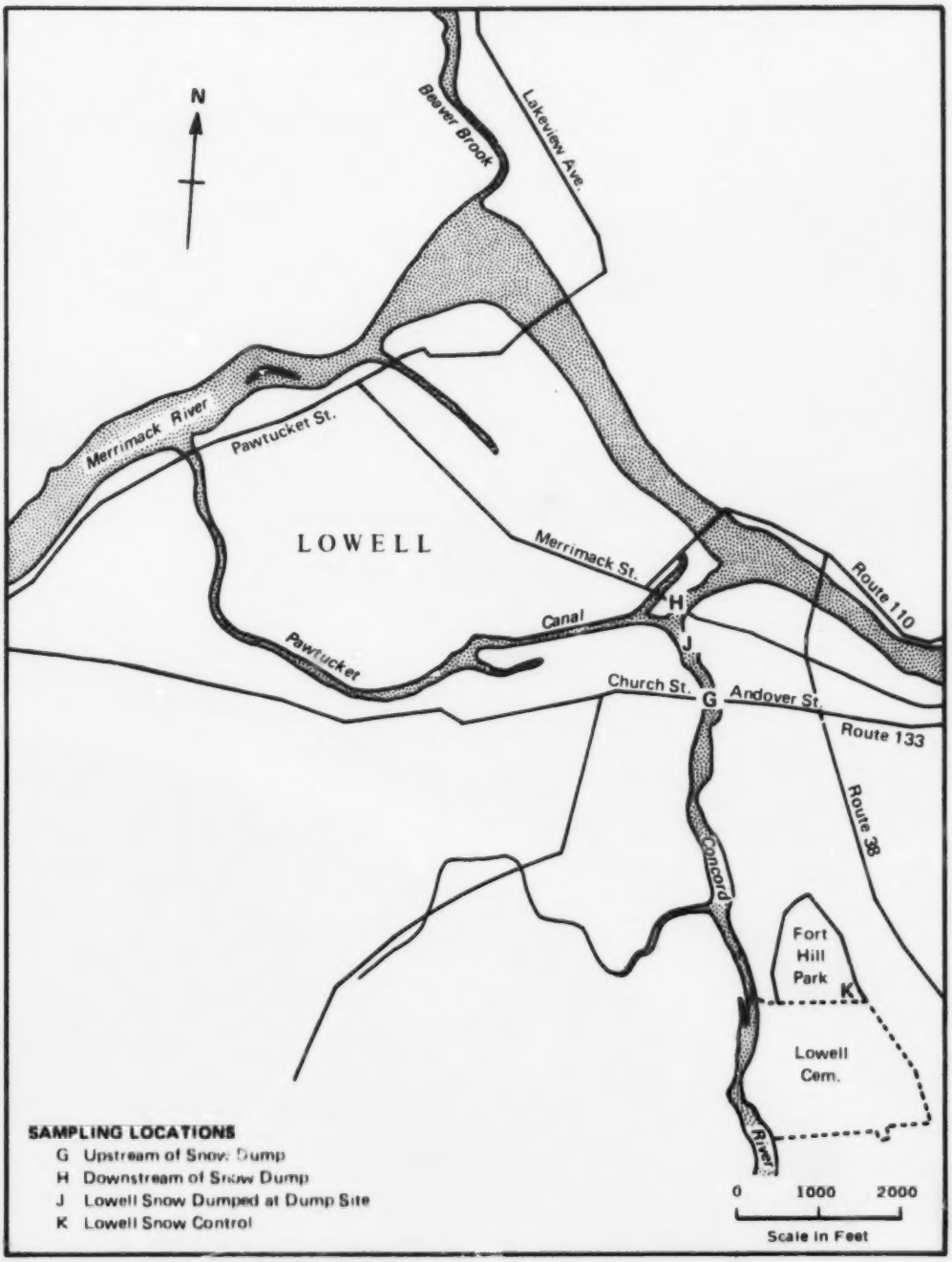


FIGURE 3 SAMPLING LOCATIONS – CONCORD RIVER, LOWELL, MASSACHUSETTS

Supporting analyses were made by Massachusetts Department of Public Works personnel.

A recent study[3] indicated that chloride levels at or near study sites A and D (Figure 4) exceeded 200 mg/1 (Cl^-). The authors concluded that the source of the chloride was not related to snow dumping practices since five samples taken during October and November 1973 from a small stream entering the Pond contained an average chloride content of more than 225 mg/1.

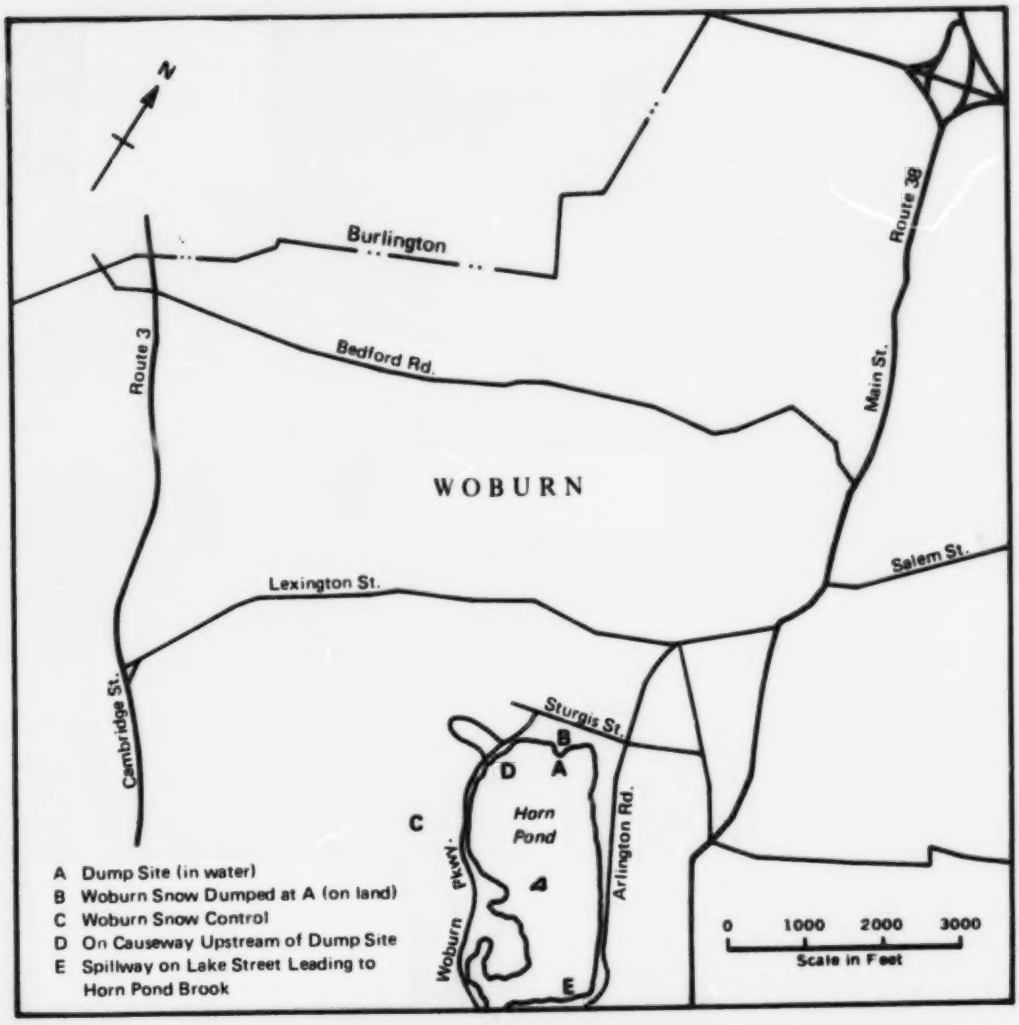


FIGURE 4 SAMPLING LOCATIONS – HORN POND, WOBURN, MASSACHUSETTS

CHEMICAL ANALYSES

SPECIES ANALYZED

A large number of chemical species or groups was selected for regular analysis on the basis of several criteria. Species such as chloride, chromium, and cyanide were measured as representatives of the direct impact of snow-dumping practices. Species such as lead, iron and oil and grease were selected to show the indirect effect of dumping caused by cars. Still other species such as mercury were analyzed in order to study the secondary effects of dumping on water quality - e.g., the possible chloride release of mercury from sediments. Other species and categories such as chemical oxygen demand (COD), phosphate, and nitrate were measured as normal indicators of water quality. The total list of species analyzed is given in Table 1, along with the analytical method used and the normal detection limits.

Analysis for mercury was performed by a flameless atomic-absorption method slightly modified to utilize the oxidizing potential of bromine. Nitrate nitrogen and ammonia nitrogen analyses were performed by use of ion-specific electrodes manufactured by Orion Research Corporation of Cambridge, Massachusetts. Analysis for cyanide was initially done by the method as described in the EPA Methods book, but was later modified to incorporate improvements suggested by EPA as indicated in ASTM Method D 2037-72. Analysis for oil and grease was done by means of the Freon 113 modification given in EPA AQC Newsletter #15, October, 1972 which allows cold extraction with the above solvent. Samples for optical emission spectroscopy were prepared by evaporation in the presence of Specpure lithium nitrate (Johnson Matthey Chemicals, London).

Table 1. CHEMICAL SPECIES, ANALYTICAL METHOD, AND DETECTION LIMIT

Species	Method	Detection Limit
Cl^-	Mercuric nitrate titration[(a)]	0.5 mg/l
CN^-	Colorimetric[(b)]	0.01 mg/l
NO_3^-/N	Ion specific electrode	0.1 mg/l
NH_3/N	Ion specific electrode	0.5 mg/l
TKN	Colorimetric[(b)]	0.05 mg/l
NO_2^-/N	Colorimetric[(b)]	2 µg/l
Total P	Colorimetric[(b)]	0.01 mg/l
COD	xs Cr_2O_7 titration[(b)]	10 mg/l
Solids -- Total Dissolved, Volatile	Gravimetric[(b)]	1 mg/l
Oil and Grease	Gravimetric[(c)]	0.5 mg/l
Na, Ca, Fe, Pb, Cr, Cu, Zn	Optical emission spectrometry	2-5 µg/element
Hg	Flameless atomic absorption	2 µg/l
Cr^{+6}	Colorimetric[(a)]	5 µg/l

(a) Standard Methods for the Examination of Water & Wastewater, 13th Edition.

(b) Methods for Chemical Analysis of Water & Wastes, 1971, EPA.

(c) Same as given in (a) with the Freon 113 modification (EPA AQC Newsletter #15, October 1972).

SAMPLE BASE/METHODS

Samples were collected from each site to be as representive as possible of

- The water at the dumping location,
- An upstream reference water sample,
- A water sample downstream from the dump site,
- The dumped snow, and
- A reference control snow sample from a nearby area.

The sampling frequency was either biweekly or monthly as shown in Table 2 and as shown specifically by date and location in Appendix A.

Collection of samples was carried out under a variety of field conditions and required only one piece of special equipment, a Van Dorn water sampler. The Van Dorn Sampler is a PVC cylinder with stoppers on each end connected internally by a piece of surgical tubing. These stoppers are hooked open, and the sampler is lowered on a nylon rope until it is 1 or 2 ft under the surface of the water. A triggering mechanism is then released (which unhooks the stoppers), the elastic surgical tube snaps the stoppers closed, and the sampler is hauled out. Then the cocks are opened and approximately 6 liters is poured into plastic bottles, coded, and recorded. This sampling method was used in Schenectady at the Freeman Street bridge (Figure 2, Location L), the railroad bridge (Figure 2, Location N) and at Lock 8 (Figure 2, Location M). It was also used in Lowell at the upstream and downstream sample locations (Figure 3, Locations G and H, respectively).

At Horn Pond samples were taken from the water's edge. The sample bottle was submerged by hand with the cap screwed on loosely. Once the bottle had been submerged, the cap was removed and the bottle filled. After removal from the water the bottle was coded.

At the snow control sites, the sampler walked into a field of virgin snow approximately thirty feet from the road, brushed the top layer of snow aside, and filled a barrel containing a plastic liner. The container was then coded and returned to the laboratory.

At the actual dump sites, the dump trucks would stop long enough for the sampler to remove from the load one or two shovelsful of snow, which were placed in a plastic-lined barrel. The procedure was repeated for three or four trucks which approximately filled the bag. The bag was then coded and returned to the laboratory.

All samples were returned to the ADL Laboratory on the day they were taken and stored at 40°F. All analyses were performed in the laboratory.

Table 2. SAMPLING FREQUENCY

Species	Samples to be Analyzed	Frequency[(a)]
Na, Ca, Fe, Pb, Cr, Cu, Zn, Hg	downstream water and snow	monthly
Cl^-, NO_3^-, PO_4^{-3}	all samples	biweekly or monthly
Solids: total, dissolved	all samples	biweekly or monthly
NH_3, TKN	all samples	biweekly or monthly
Oil and Grease	snow and downstream samples	biweekly or monthly
COD	all samples	biweekly or monthly
CN^-	all samples	biweekly or monthly
Hg	sediments	several samples
Cr^{+6}	all samples	monthly

(a) depending on season

DATA ANALYSIS

All of the analytical results obtained on the various samples are grouped according to the species analyzed and are tabulated in the Appendix. In order to facilitate analysis, some of the results have been presented graphically in Figures 5-15 at the end of this section. These figures present upstream (solid line) and downstream (dash line) results for chloride, nitrate, phosphate, total chromium, lead, iron, total solids and total dissolved solids. The arrows along the calendar axis of the graph indicate the dates on which snow was dumped at the site and snow samples were collected. As the figures indicate, there was limited or no dumping (Woburn after February 1973) at the sites due to the unusually low snowfall and to a reduction in snow loading and hauling occasioned by the fuel shortage during the 1973-74 winter season. Most agencies used their fuel allocation for plowing operations. Therefore, interpretation of these data must be made with this in mind.

Under the minimal conditions observed, snow dumping had little direct impact on the downstream concentration of any species (compare dashed and solid lines). Little effect was noticeable particularly at Horn Pond where the effect should have been most readily observed since flow conditions in the Pond are the lowest of the three sites that were studied.

The data for chloride (Figure 5) suggests a general impact of salting on chloride levels, but this must be the result of indirect runoff effects since both upstream and downstream levels are the same. It is interesting to note that the summer concentration due to low flow and reduced dilution volume is as great as that during the winter when salt is being used. Other interesting changes are observed, such as the nitrate peak during May and June (Figure 6), but once again, this change appears not to be attributable to the practice of snow removal and dumping since levels upstream and downstream are the same.

Of the variations observed in phosphate levels (Figure 7), none seem to be associated with the periods of heavy salt usage. The total chromium levels (Figure 8) do appear to be higher during the winter. Similar trends were not observed for lead (Figure 9) and iron (Figure 10).

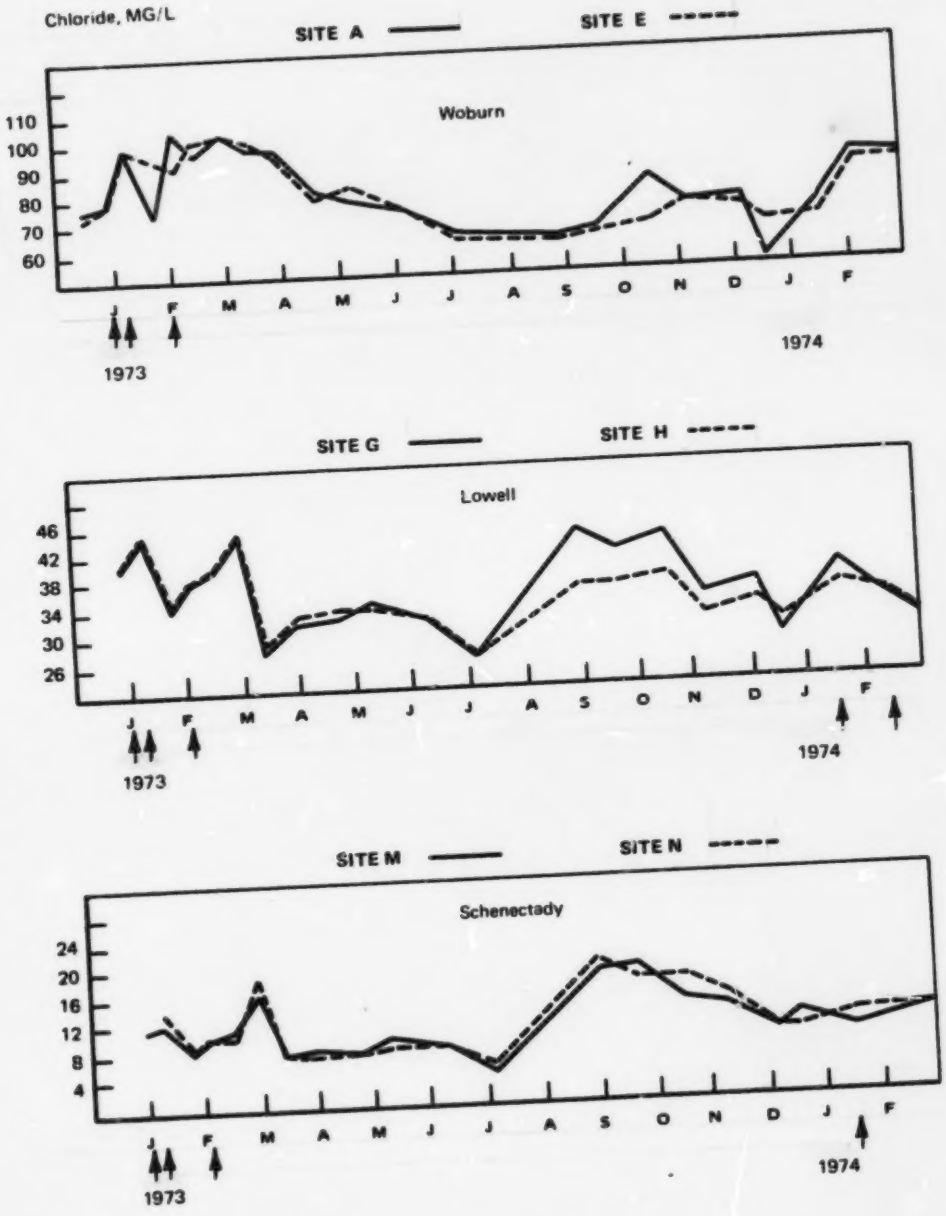
The relatively toxic cyanide species, which could be released from the anti-caking agents in the salt, is only observed in the dump snow samples--none could be detected in any of the water samples.

The concentrations of total solids (Figure 11) and total dissolved solids (Figure 12) both varied similarly to the variation observed for chloride. These levels would indicate that the concentrations are attributable to normal flow variation in the three sampling areas.

In Figures 13-15, the levels of chloride, nitrate, and lead are compared as measures of three different water quality contributors for the downstream values at each of three sites. There is no apparent correlation between these different measures of water quality and the chloride levels either as a measure of total salting practice or as a measure of snow dumping.

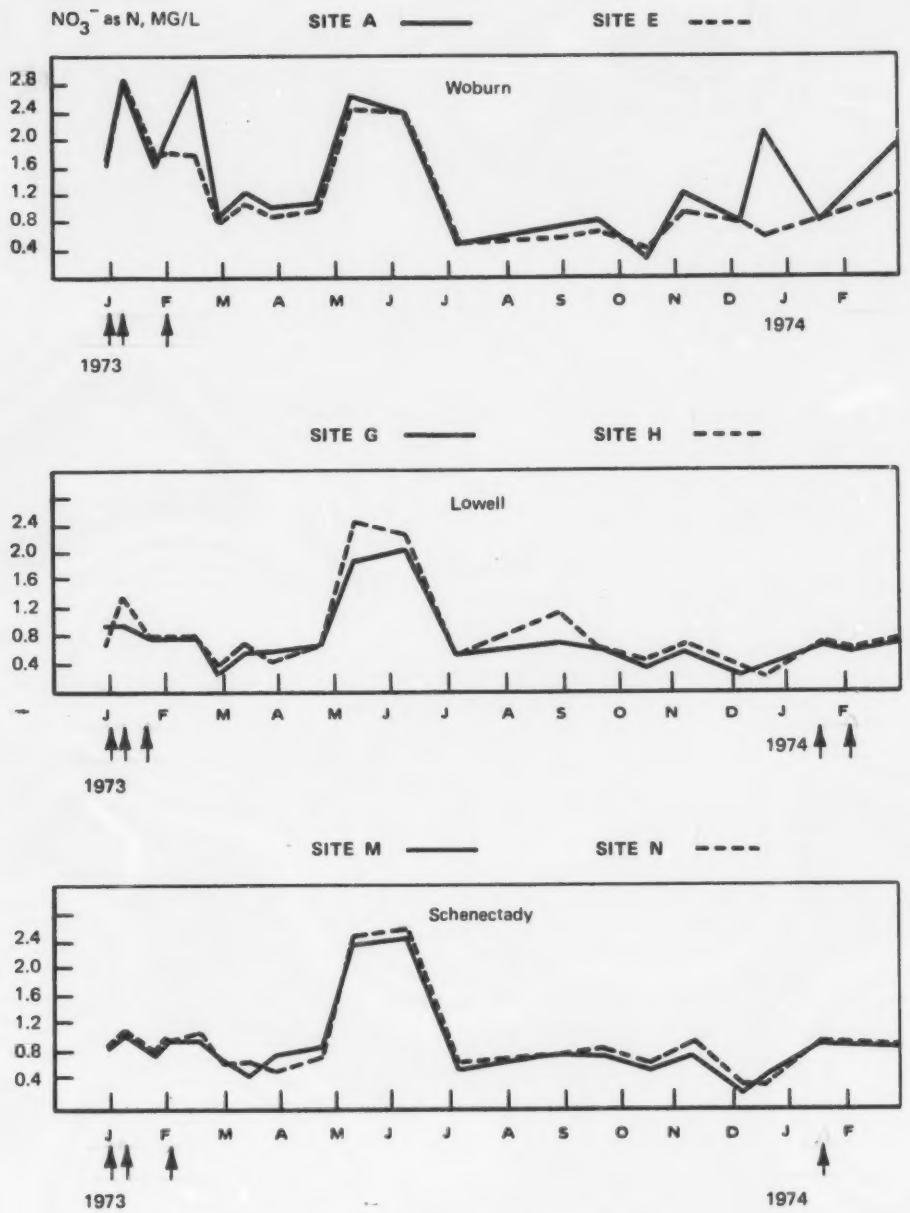
The results of this study are in agreement with those of the Ottawa study[2] previously discussed. For all of the species analyzed, there was no significant difference between upstream and downstream concentration levels that could be attributable to dumping of snow. These results are not at all surprising when one considers the large dilution volume into which a relatively small amount of snow is dumped at any one time.

As a worst case example, calculations were made of the impact of dumping into Horn Pond in Woburn from a single storm. It was assumed that the snow is only diluted by the holding volume of pond. The pond has an area of about 5×10^5 square meters and an average depth of 6 meters for a volume 3×10^6 cu meters. During the February 1, 1973 storm, the measured average chloride concentration was 680 mg/l in the snow dumped into the pond. About 100 truck loads of snow were dumped, each with an average load of 1800 kg (2 tons), resulting in about 120 kg of chloride dumped with the snow. (Normal seasonal snowfall would result in significant increases in total amounts dumped.) If this chloride was thoroughly mixed with the total volume in the Pond, it would result in a concentration of only 0.04 mg/l, or less than the precision (0.5 mg/l) of the assay technique for chloride. The direct impact of such dumping in the high flow river sites would have been even less.



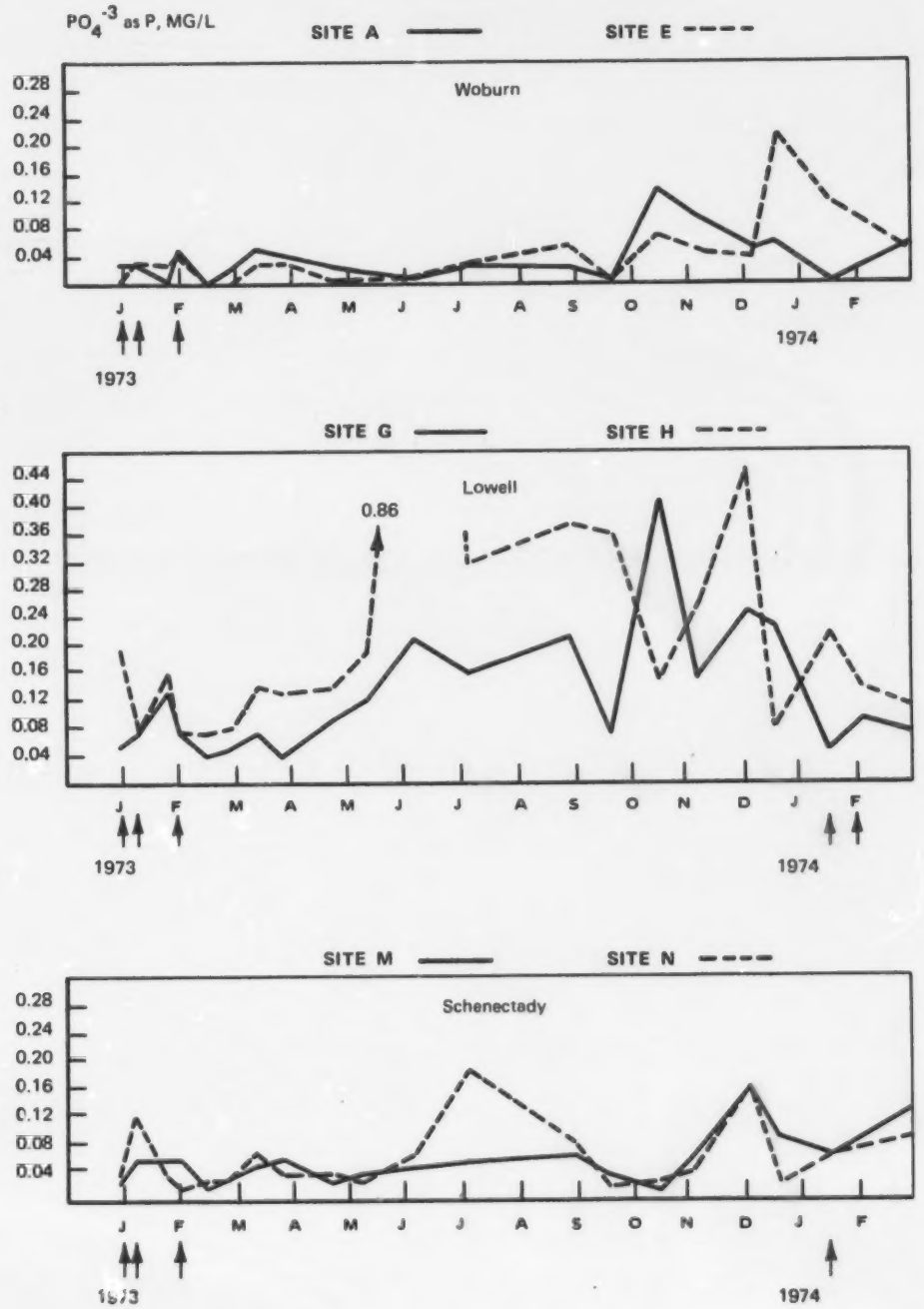
Arrows are snow dump dates.

FIGURE 5 CHLORIDE CONCENTRATION LEVELS



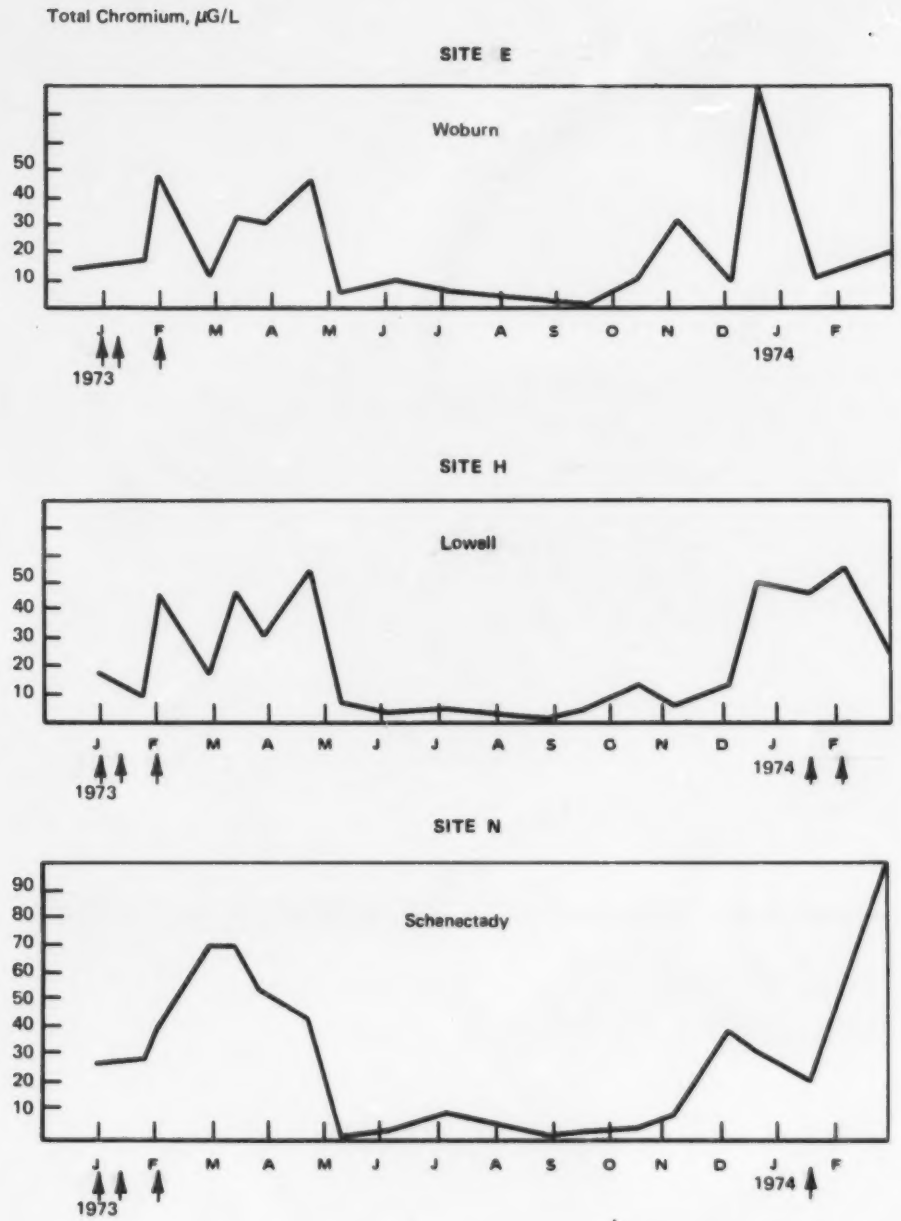
Arrows are snow dump dates.

FIGURE 6 NITRATE CONCENTRATION LEVELS



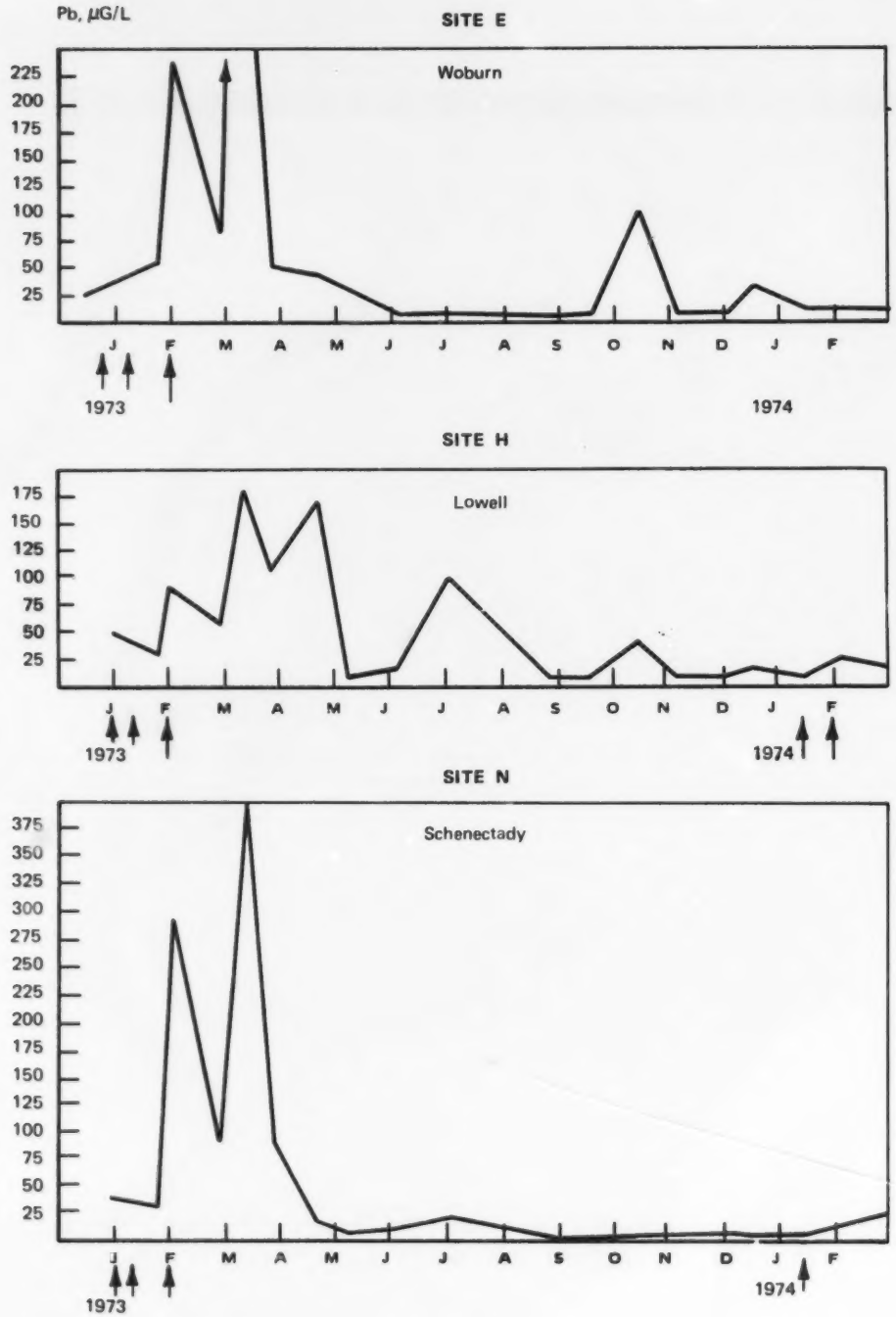
Arrows are snow dump dates.

FIGURE 7 PHOSPHATE CONCENTRATION LEVELS



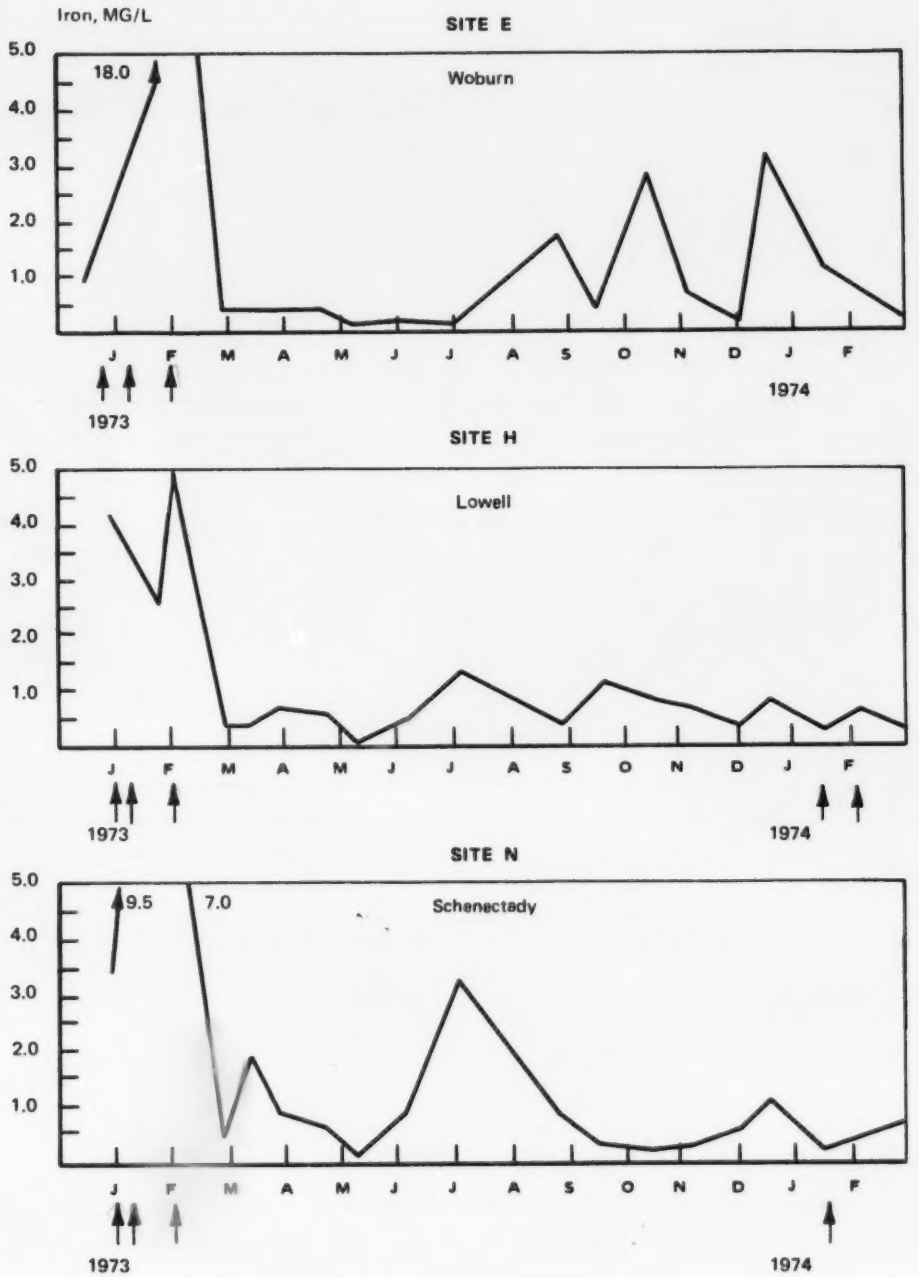
Arrows are snow dump dates.

FIGURE 8 CHROMIUM CONCENTRATION LEVELS



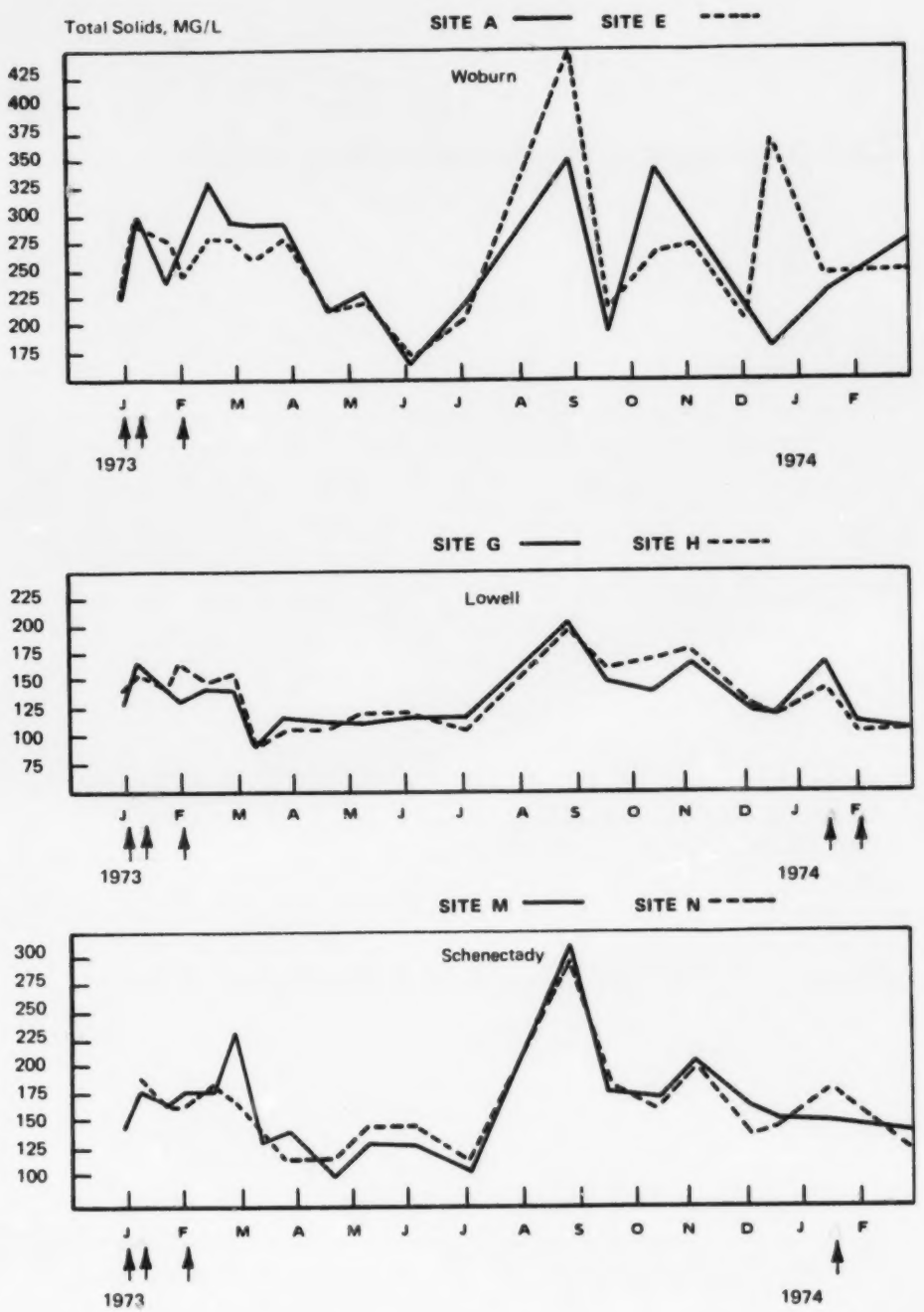
Arrows are snow dump dates.

FIGURE 9 LEAD CONCENTRATION LEVELS



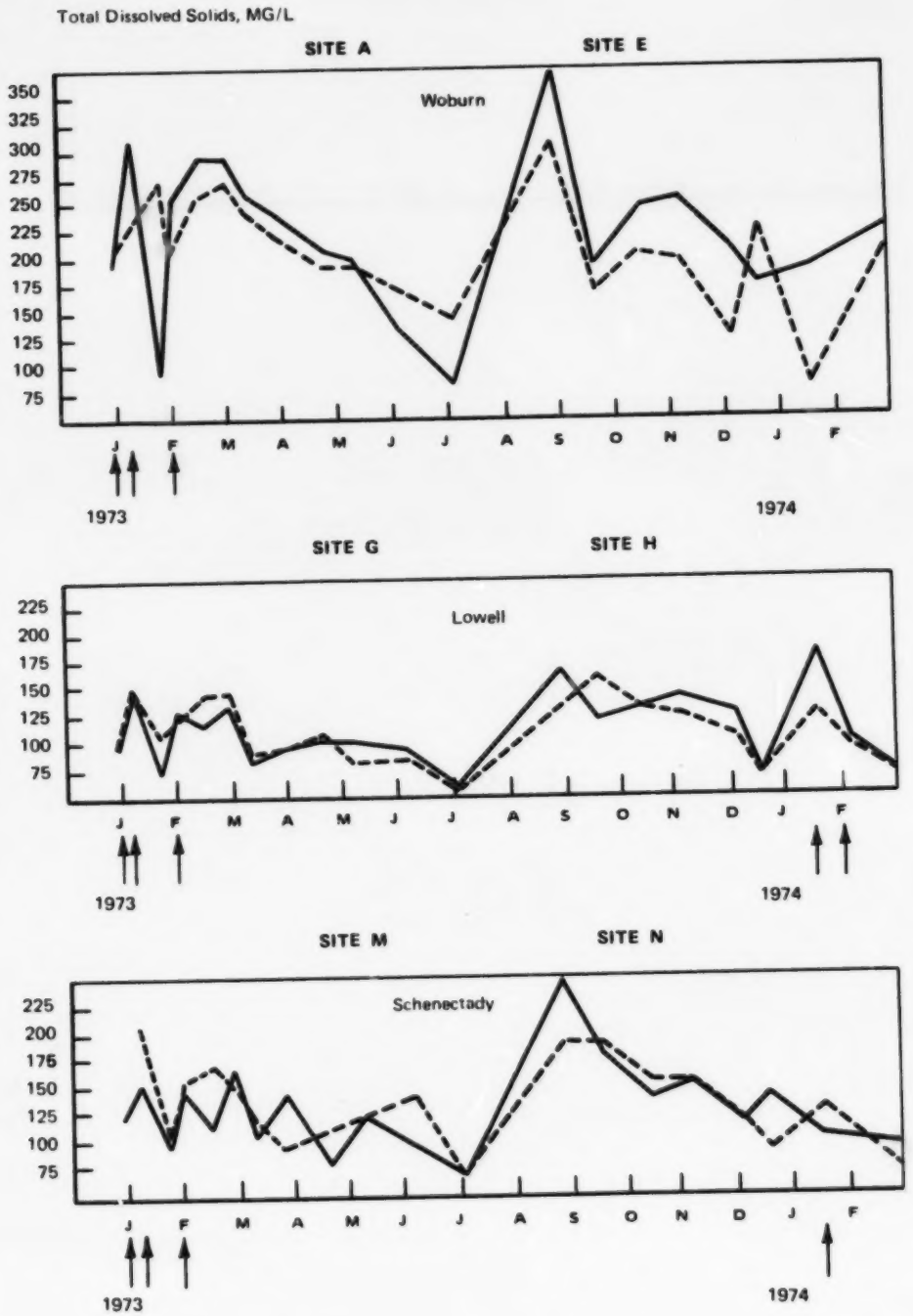
Arrows are snow dump dates.

FIGURE 10 IRON CONCENTRATION LEVELS



Arrows are snow dump dates.

FIGURE 11 TOTAL SOLIDS CONCENTRATIONS



Arrows are snow dump dates.

FIGURE 12 TOTAL DISSOLVED SOLIDS CONCENTRATION LEVELS

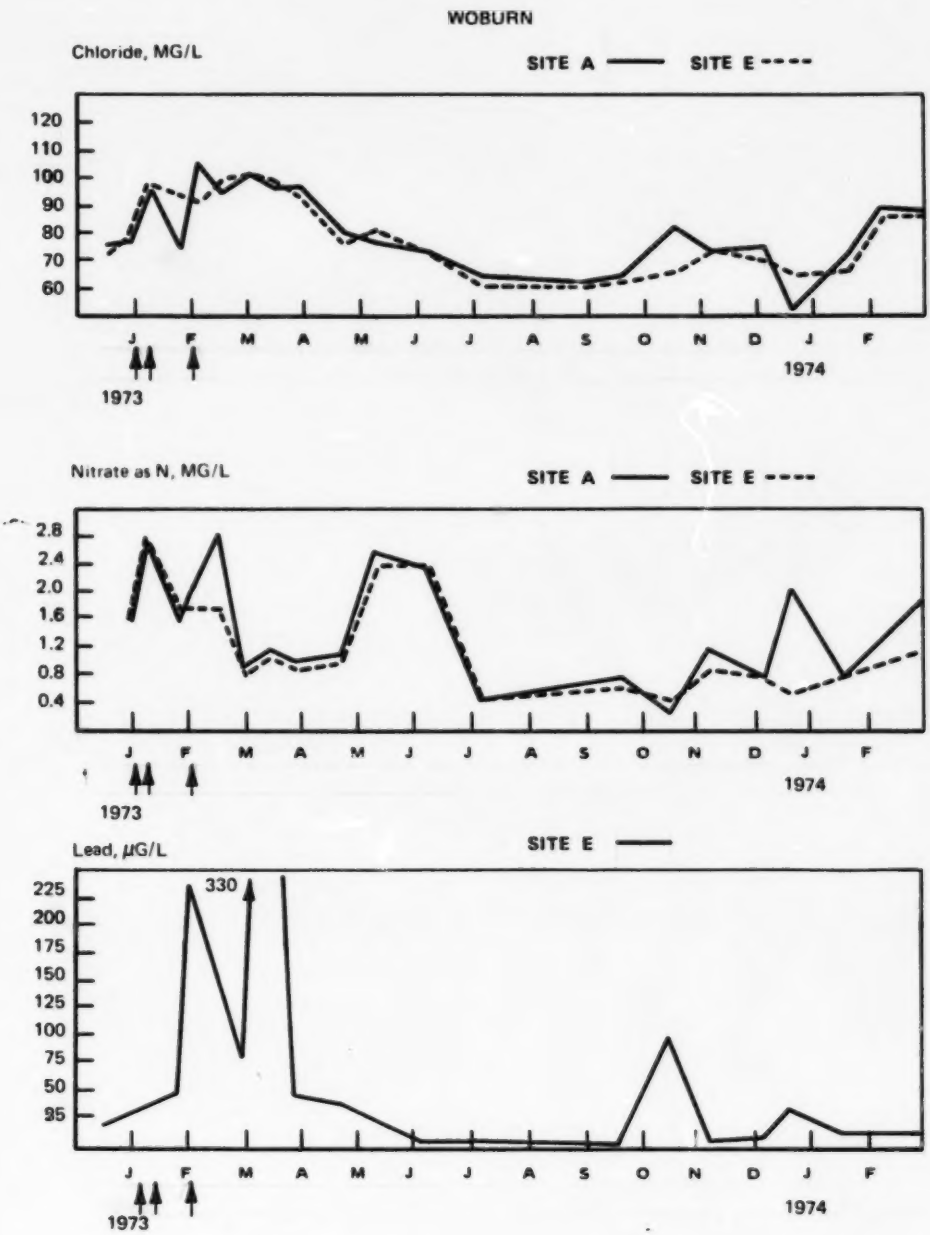
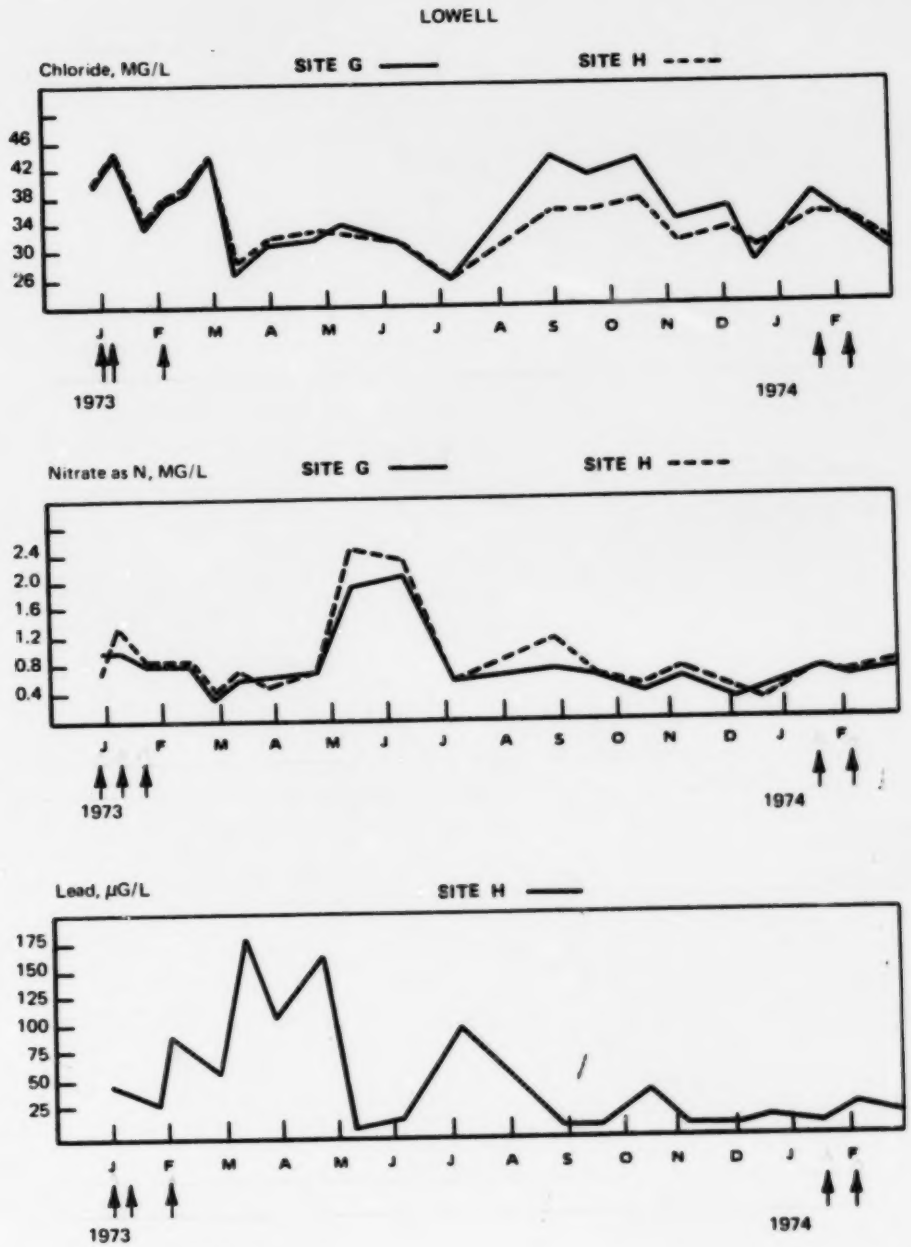


FIGURE 13 COMPARISON OF WOBURN CHLORIDE, NITRATE AND LEAD VALUES



Arrows are snow dump dates.

FIGURE 14 COMPARISON OF LOWELL CHLORIDE, NITRATE AND LEAD VALUES

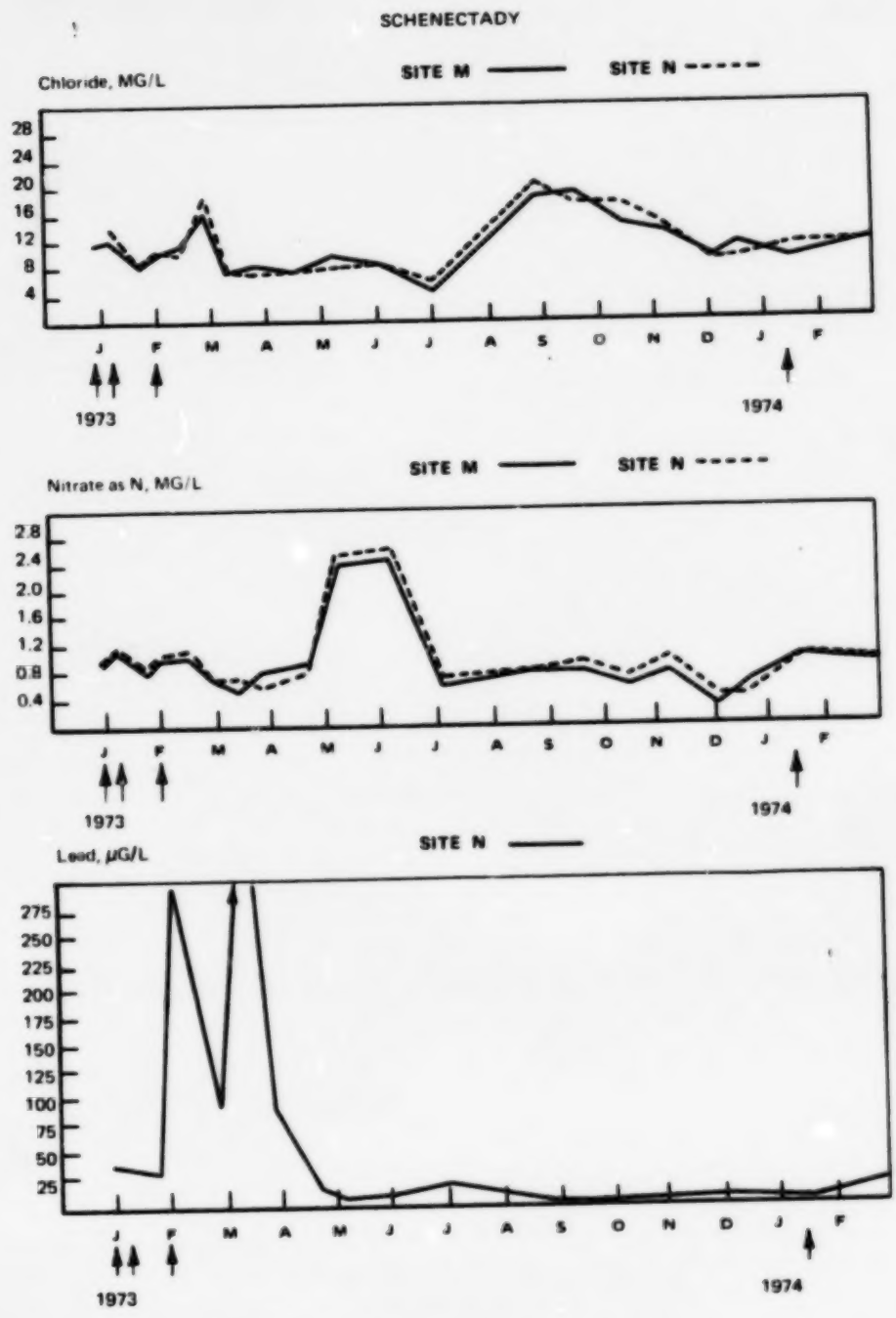


FIGURE 15 COMPARISON OF SCHENECTADY CHLORIDE, NITRATE AND LEAD VALUES

REFERENCES

1. Sylvester, R.O., Dewalle, F., Character and Significance of Highway Runoff Waters: A Preliminary Appraisal, Washington State Highway Commission, Department of Highways/Federal Highway Administration (NTIS/PB-220 083), 1972, 97 p.

2. Desmaris, J.N., Pollutional Aspects of Snow Disposal, Road and Transportation Association of Canada, First National Snow Conference, Ottawa, April 16-18, 1973, 32 p.

3. Habitat, Inc., Horn Pond Water Quality Survey, The Habitat School of Environment, Belmont, Ma. 02178, 1973.

APPENDIX A

CHEMICAL ANALYSIS DATA SHEETS

	Table
Chloride	A-1
Cyanide	A-1
Nitrate Nitrogen	A-2
Total Phosphorus	A-2
Ammonia Nitrogen	A-3
Total Kjeldahl Nitrogen	A-3
Chromium	A-4
Cr^{+6}	A-4
Copper	A-5
Lead	A-5
Iron	A-6
Zinc	A-6
Sodium	A-7
Calcium	A-7
Mercury	A-8
Nitrite nitrogen	A-8
Total Solids	A-9
Dissolved Solids	A-9
Oil and grease	A-10
COD	A-10
Loss on ignition	A-11

TABLE A–1 SUMMARY OF SAMPLING ANALYSES

Chloride, milligrams per liter

SAMPLING SITES	Code	12/26	1/9	1/22	2/11	2/13	3/26	3/28	4/26	5/7	6/5	7/2	8/5	9/17	10/4	11/5	12/3	12/12	1/5	2/5	2/27
Woburn, MA																					
Dump Site	A	78	77	92	72	102	94	101	96	95	80	76	71	64	62	65	83	72	73	51	72	90	87
Dumped Snow Melt	B				679																		
Control Snow	C				505																		
Upstream	D	73	62	89	99	77	78	66	69	73	64	66	62	35	60	63	68	57	73	73	69	87	86
Downstream	E	72	78	98	93	90	99	101	92	94	78	81	71	62	61	69	67	72	71	66	68	86	88
Lowell, MA																							
Upstream	G		40	44	34	37	39	44	27	31	32	34	32	26	44	41	43	34	36	28	38	34	30
Downstream	H		40	44	38	37	39	44	28	32	33	33	32	26	36	36	32	31	33	30	35	34	30
Dumped Snow Melt	J		113	56																	176	186	
Control Snow	K				505																2	13	
Schenectady, NY																							
Upstream	L		13	14	8	10	11	20	8	8	8	9	8	5	20	17	18	17	8	–	10		10
Far Upstream	M		11	12	8	10	11	16	7	8	7	9	8	9	18	19	14	13	9	11	9		11
Downstream	N			14	8	10	10	18	7	7	7	8	8	5	20	17	17	14	9	9	11		11
Dumped Snow Melt	P			5		709															284		
Control Snow	Q					0.7															505		

Lower limit of detection 0.5 mg/L

Analysis method MERCURIC NITRATE TITRATION "STANDARD METHODS" 13TH ED

Cyanide, milligrams per liter

SAMPLING SITES	Code	12/26	1/9	1/22	2/11	2/13	3/26	3/28	4/26	5/7	6/5	7/2	8/5	9/17	10/4	11/5	12/3	12/12	1/5	2/5	2/27
Woburn, MA																					
Dump Site	A	<.001	<.001	<.001	<.001	<.001												<.001	<.001	<.001	
Dumped Snow Melt	B				0.09																
Control Snow	C				<.001																
Upstream	D	<.001	<.001	<.001	<.001	<.001												<.001	<.001	<.001	
Downstream	E	<.001	<.001	<.001	<.001	<.001												<.001	<.001	<.001	
Lowell, MA																					
Upstream	G	<.001	<.001	<.001	<.001	<.001												<.001	<.001	<.001	
Downstream	H	<.001	<.001	<.001	<.001	<.001												<.001	<.001	<.001	
Dumped Snow Melt	J	1.32	0.02																.006	.006	
Control Snow	K				<.001														<.001	<.001	
Schenectady, NY																					
Upstream	L		<.001	<.001	<.001	<.001												<.001	–	<.001	
Far Upstream	M		<.001	<.001	<.001	<.001												<.001	<.001	<.001	
Downstream	N		<.001	<.001	<.001	<.001												<.001	<.001	<.001	
Dumped Snow Melt	P	<.001			0.01														0.10		
Control Snow	Q				<.001														<.001		

SAMPLES FOR CYANIDE ANALYSIS WERE NOT TAKEN DURING THIS PERIOD

Lower limit of detection 0.001 mg/L

Analysis method EPA "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES" 1971

TABLE A–2 SUMMARY OF SAMPLING ANALYSES

Nitrate Nitrogen, Milligrams per Liter

SAMPLING SITES	Code	12/5	12/6	12/9	12/22	1/30	2/12	2/26	3/4	3/24	3/25	4/8	4/9	5/2	6/5	7/2	8/28	9/2	10/4	11/5	12/3	12/27	1/15	2/5	2/27
Woburn MA																									
Dump Site	A		1.7	2.8		1.6	2.0	2.9		0.89	1.2		0.99	1.1	2.6	2.9	0.95	0.68	0.75	0.32	1.2	0.79	2.1	0.75		1.9
Dumped Snow Melt	B						2.6																		
Control Snow	C						<0.1																		
Upstream	D		1.9	3.2	1.3	2.9	2.7	0.95	0.31	1.2	1.2	2.9	2.5	0.94	0.66	0.57	0.93	0.90	0.77	0.59	0.77				1.2
Downstream	E		1.6	7.0	1.7	1.9	1.8	0.75	1.1	0.86	1.0	2.9	2.4	0.95	0.97	0.66	0.29	0.32	0.91	0.39	0.77				1.2
Lowell MA																									
Upstream	G		1.0	1.0	0.8	0.8	0.8	0.34	0.63	0.63	0.72	1.9	2.1	0.47	0.75	0.68	0.52	0.61	0.32	0.91	0.66	0.59	0.68		
Downstream	H		0.7	1.9	0.8	0.8	0.8	0.91	0.32	0.50	0.72	2.5	2.3	0.95	1.2	0.72	0.47	0.68	0.38	0.32	0.72	0.59	0.68		
Dumped Snow Melt	J		0.8	0.9																					
Control Snow	K						<0.1															0.27	0.38		
Schenectady NY																									
Upstream	L		1.0	1.1	0.8	1.0	1.0	0.80	0.58	1.0	0.90	2.5	2.6	0.94	0.81	0.93	0.84	0.91	0.93		1.0		0.93		
Mid Upstream	M		0.9	1.1	0.8	1.0	1.1	0.72	0.70	0.61	0.84	2.5	2.6	0.66	0.75	0.56	0.65	0.97	0.93	0.93	1.0		0.95		
Downstream	N		0.9	1.1	0.8	1.0	1.0	0.72	0.52	0.79	0.93	2.4	2.5	0.61	0.75	0.81	0.59	0.81	0.82	0.50	1.0		0.93		
Dumped Snow Melt	P		0.5				2.4																		
Control Snow	Q						0.2															0.52			

Lower limit of detection 0.1 Mg/L — Analysis method ION SPECIFIC ELECTRODE

Total Phosphorus, Milligrams per Liter

SAMPLING SITES	Code	12/5	12/6	12/9	12/22	1/30	2/12	2/26	3/4	3/24	3/25	4/8	4/9	5/2	6/5	7/2	8/28	9/2	10/4	11/5	12/3	12/27	1/15	2/5	2/27
Woburn MA																									
Dump Site	A		0.03	0.03	0.01	0.1	<0.01	0.02	0.05				0.03	0.02	0.01	0.03	0.03	<0.01	0.14	0.10	0.05	0.06	0.01		0.06
Dumped Snow Melt	B																								
Control Snow	C					<0.01	<0.01																		
Upstream	D		0.01	0.02	0.03	0.02	0.1	<0.01	0.03	0.03	0.03	0.03	0.02	0.03	0.09	0.02	0.01	0.05	0.02	0.03	0.29	0.02			0.03
Downstream	E		0.01	0.03	0.03	0.04	<0.1	<0.01	0.03	0.03	0.01		0.01	0.03	0.06	0.01	0.07	0.05	0.04	0.22	0.12				0.05
Lowell MA																									
Upstream	G		0.05	0.07	0.15	0.07	0.04	0.05	0.07	0.09	0.09	0.12	0.21	0.16	0.21	0.07	0.41	0.15	0.25	0.29	0.05	0.09	0.07		
Downstream	H		0.19	0.08	0.16	0.07	0.07	0.08	0.14	0.13	0.14	0.19	0.86	0.32	0.38	0.36	0.15	0.26	0.45	0.08	0.22	0.14	0.11		
Dumped Snow Melt	J		0.07	0.36																	0.41	0.21			
Control Snow	K						0.01														0.06	0.01			
Schenectady NY																									
Upstream	L		0.04	0.09	0.07	0.05	0.01	0.05	0.04	0.06	0.05	0.06	0.07	0.21	0.14	0.09	0.07	<0.01	0.15		0.06		0.13		
Mid Upstream	M		0.12	0.06		0.06	0.02	0.03	0.05	0.06	0.03	0.04	0.05	0.06	0.07	0.04	0.02	0.03	0.17	0.10	0.07		0.14		
Downstream	N		0.04	0.12	0.09	0.02	0.03	0.03	0.07	0.07	0.09	0.03	0.07	0.19	0.09	0.03	0.03	0.09	0.17	0.03	0.07		0.10		
Dumped Snow Melt	P		0.68																		0.49				
Control Snow	Q						0.01														0.03				

Lower limit of detection 0.01 Mg/L — Analysis method "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES," 1971, EPA

TABLE A–3 SUMMARY OF SAMPLING ANALYSES

Ammonia nitrogen, milligrams per liter

SAMPLING SITES	Code	12/5	12/26 12/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	2/12	2/26	3/12	3/25 3/26	4/19 4/19	5/7	6/5	7/2	8/28	9/17	10/14	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A																						
Dumped Snow Melt	B																						
Control Snow	C																						
Upstream	D																						
Downstream	E				0.7	0.25	0.2	1.5	0.3	0.05								0.3	0.2	0.6	0.3		0.4
Lowell, MA																							
Upstream	G																						
Downstream	H				1.4	0.4	0.2	0.8	0.3	0.2	SAMPLES NOT TAKEN							0.3	0.7	0.5	0.6	-	0.3
Dumped Snow Melt	J										DURING THIS PERIOD										0.3		
Control Snow	K																						
Schenectady, NY																							
Upstream	L																						
Far Upstream	M																						
Downstream	N				0.7	0.2	<0.05	0.2	0.3	0.1								0.2	0.2	0.4	0.1		0.2
Dumped Snow Melt	P																				0.3		
Control Snow	Q																						

Lower limit of detection 0.05 MG/L

Analysis method EPA "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES," 1971
ION SELECTIVE ELECTRODE USE BEGUN IN 12/73

Total Kjeldahl nitrogen, milligrams per liter

SAMPLING SITES	Code	12/5	12/26 12/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	2/12	2/26	3/12	3/25 3/26	4/19 4/19	5/7	6/5	7/2	8/28	9/17	10/14	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A																						
Dumped Snow Melt	B																						
Control Snow	C																						
Upstream	D																						
Downstream	E				1.5	0.5	1.3	2.2	0.3	0.8								0.4	2.6	1.2		1.0	
Lowell, MA																							
Upstream	G																						
Downstream	H				3.0	0.4	0.2	1.2	0.6	1.0	SAMPLES NOT ANALYZED FOR							2.2	1.2	2.1	1.0		1.1
Dumped Snow Melt	J										TKN IN DURING THIS PERIOD										4.1	9.7	
Control Snow	K																				0.5		
Schenectady, NY																							
Upstream	L																						
Far Upstream	M																						
Downstream	N				<0.5	0.5	<0.1	0.6	0.9	0.6								0.4	-	0.7		1.3	
Dumped Snow Melt	P																			1.8			
Control Snow	Q																						

Lower limit of detection 0.05 MG/L

Analysis method EPA "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES," 1971

TABLE A–4 SUMMARY OF SAMPLING ANALYSES

Chromium, micrograms per liter

SAMPLING SITES	Code	12/5	12/26 1/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	4/12	3/26	3/2	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/21	9/12	10/4	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A																						
Dumped Snow Melt	B																						
Control Snow	C																						
Upstream	D	20				24																	
Downstream	E	14			17	48		11	32	30	45	5	10	6	2	<2	10	31	10	82	10		20
Lowell, MA																							
Upstream	G		14																				
Downstream	H		17		10	46		18	46	31	55	7	4	5		5	14	7	14	50	48	56	25
Dumped Snow Melt	J																						
Control Snow	K																						
Schenectady, NY																							
Upstream	L																						
Far Upstream	M		26																				
Downstream	N		27		29	41		70	70	54	44	2	4	10	2	2	8	10	40	33	22		100
Dumped Snow Melt	P																						
Control Snow	Q																						

Lower limit of detection 2-5 MICROGRAMS PER LITER Analysis method OPTICAL EMISSION SPECTROMETRY

Cr^{+6} micrograms per liter

SAMPLING SITES	Code	12/5	12/26 1/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	4/12	3/26	3/2	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/21	9/12	10/4	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A						5	17							4	4	2	5	3	4	5		12
Dumped Snow Melt	B					4																	
Control Snow	C																						
Upstream	D						4	7							4	6	2	5	4	20	5		16
Downstream	E					4	8	5							6	3	5	10	4	12	3		16
Lowell, MA																							
Upstream	G					7	10	NO ANALYSES MADE							7	8	7	17	4	12	7	9	20
Downstream	H					6	14	14	DURING THIS PERIOD						10	19	12	27	9	8	14	14	20
Dumped Snow Melt	J																				74	56	
Control Snow	K																				2	3	
Schenectady, NY																							
Upstream	L						20	19							12	5	4	19	12	-	11		26
Far Upstream	M						17	16							7	4	4	8	17	32	12		28
Downstream	N					8	17	18							6	4	4	17	14	37	11		29
Dumped Snow Melt	P					13															61		
Control Snow	Q																				3		

Lower limit of detection 5 MICROGRAMS PER LITER Analysis method "STANDARD METHODS," 13TH ED

TABLE A–5 SUMMARY OF SAMPLING ANALYSES

Copper, micrograms per liter

SAMPLING SITES	Code	Date 12/15	12/26	1/9	1/22	1/30	2/1	2/12	2/26	3/12	3/25	3/26	4/19	5/7	6/5	7/2	8/28	9/17	10/4	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																									
Dump Site	A																								
Dumped Snow Melt	B																								
Control Snow	C																								
Upstream	D	31				230																			
Downstream	E	45			87	370		220	190	770	920	52	500	65	60	14	191	70	51	51	99		11		
Lowell, MA																									
Upstream	G		440																						
Downstream	H		130		58	950		240	83	530	800	6	92	85	28	62	130	180	110	320	55	11	75		
Dumped Snow Melt	J																								
Control Snow	K																								
Schenectady NY																									
Upstream	L																								
Far Upstream	M		49																						
Downstream	N		54		82	280		230	340	190	520	10	110	75	15	54	26	75		90	28		300		
Dumped Snow Melt	P																								
Control Snow	Q																								

Lower limit of detection 2-5 MICROGRAMS/LITER Analysis method OPTICAL EMISSION SPECTROMETRY

Lead, micrograms per liter

SAMPLING SITES	Code	Date 12/15	12/26	1/9	1/22	1/30	2/1	2/12	2/26	3/12	3/25	3/26	4/19	5/7	6/5	7/2	8/28	9/17	10/4	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																									
Dump Site	A																								
Dumped Snow Melt	B																								
Control Snow	C																								
Upstream	D	92				165																			
Downstream	E	25			54	240		78	330	50	95	<10	<10	10	6	10	100	11	10	36	14		13		
Lowell, MA																									
Upstream	G		300																						
Downstream	H		49		32	91		58	180	108	165	10	18	100	8	10	90	11	<10	13	10	25	18		
Dumped Snow Melt	J																								
Control Snow	K																								
Schenectady NY																									
Upstream	L																								
Far Upstream	M		46																						
Downstream	N		43		33	300		94	410	93	<20	<10	15	23	6	3	5	10	11	7	<10		23		
Dumped Snow Melt	P																								
Control Snow	O																								

Lower limit of detection 2-5 µg/LITER Analysis method OPTICAL EMISSION SPECTROMETRY

TABLE A–6 SUMMARY OF SAMPLING ANALYSES

Iron, milligrams per liter

SAMPLING SITES	Code	Date 12/5	12/26 12/27	1/9 1/10	1/22 1/23	1/30 2/1 2/3	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/28	9/17	10/14	11/15	12/3	12/17	1/15	2/15	2/27
Woburn, MA																							
Dump Site	A																						
Dumpsite Snow Melt	B																						
Control Snow	C																						
Upstream	D	2.6																					
Downstream	E	1.0			45	18.0		0.35	0.35	0.38	0.32	0.04	0.16	0.10	1.70	0.40	2.80	0.67	0.24	3.10	1.20		0.21
Lowell, MA																							
Upstream	G		2.6																				
Downstream	H		4.2		2.6	5.0		0.40	0.39	0.67	0.56	0.06	0.34	1.40	0.37	1.10	0.78	0.65	0.35	0.75	0.34	0.56	0.27
Dumpsite Snow Melt	J																						
Control Snow	K																						
Schenectady, NY																							
Upstream	L																						
Far Upstream	M		5.8																				
Downstream	N		3.5		95	7.0		0.34	1.90	1.02	0.08	0.12	0.96	3.40	0.87	0.38	0.29	0.42	0.70	1.20	0.25		0.75
Dumpsite Snow Melt	P																						
Control Snow	Q																						

Lower limit of detection 2-5 µg Analysis method OPTICAL EMISSION SPECTROMETRY

Zinc, micrograms per liter

SAMPLING SITES	Code	Date 12/5	12/26 12/27	1/9 1/10	1/22 1/23	1/30 2/1 2/3	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/28	9/17	10/14	11/15	12/3	12/17	1/15	2/15	2/27
Woburn, MA																							
Dump Site	A																						
Dumpsite Snow Melt	B																						
Control Snow	C																						
Upstream	D	<50				<50																	
Downstream	E	<50		<50	<50		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Lowell, MA																							
Upstream	G		<50																				
Downstream	H		<50	<50	<50		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Dumpsite Snow Melt	J																						
Control Snow	K																						
Schenectady, NY																							
Upstream	L																						
Far Upstream	M		<50																				
Downstream	N		<50	<50	<50		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Dumpsite Snow Melt	P																						
Control Snow	Q																						

Lower limit of detection 2-5 µg Analysis method OPTICAL EMISSION SPECTROMETRY

TABLE A–7 SUMMARY OF SAMPLING ANALYSES

Sodium, milligrams per liter

SAMPLING SITES	Code	12/5	12/26 12/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/-	8/28	9/17	10/14	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A																						
Dumped Snow Melt	B																						
Control Snow	C																						
Upstream	D	25				34																	
Downstream	E	24			44	34		18	17	15	12	3	4	9	22	17	23	15	18	18	24		19
Lowell, MA																							
Upstream	G		14																				
Downstream	H		25		16	17		10	10	10	9	8	6	9	18	15	18	12	10	11	15	12	14
Dumped Snow Melt	J																						
Control Snow	K																						
Schenectady, NY																							
Upstream	L																						
Far Upstream	M		5																				
Downstream	N		5		4	11		8	3	2	2	3	2	5	10	8	9	10	8	4	7		4
Dumped Snow Melt	P																						
Control Snow	Q																						

Lower limit of detection 2-5 MICROGRAMS PER LITER Analysis method OPTICAL EMISSION SPECTROMETRY

Calcium, milligrams per liter

SAMPLING SITES	Code	12/5	12/26 12/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/28	9/17	10/14	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A																						
Dumped Snow Melt	B																						
Control Snow	C																						
Upstream	D	45				16																	
Downstream	E	44			36	12		37	35	25	21	24	13	20	10	11	10	8	9	12	9		10
Lowell, MA																							
Upstream	G		18																				
Downstream	H		32		11	8		21	14	20	13	25	20	33	7	5	9	9	9	8	11	11	8
Dumped Snow Melt	J																						
Control Snow	K																						
Schenectady, NY																							
Upstream	L																						
Far Upstream	M		65																				
Downstream	N		40		34	15		41	29	26	36	12	28	39	7	11	7	11	13	19	18		15
Dumped Snow Melt	P																						
Control Snow	Q																						

Lower limit of detection 2-5 MICROGRAMS PER LITER Analysis method OPTICAL EMISSION SPECTROMETRY

TABLE A–8 SUMMARY OF SAMPLING ANALYSES

Mercury, micrograms per liter

SAMPLING SITES	Code	Date 12/5	12/26	1/9	1/22	1/30 2/1	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/28	9/17	10/4	11/5	12/3	12/17	1/15	2/5	2/27	BOTTOM TAKEN	SAMPLES 12/14/73
Woburn, MA																									
Dump Site	A						<2	<2	<2	3	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		
Dumped Snow Melt	B																								
Control Snow	C																								
Upstream	D	160			30	160	5	<2	5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		
Downstream	E	30			150	40	5	<2	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	560	
Lowell, MA																									
Upstream	G		140		50	165	2	<2	<2	<2	<2	<2	3	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		
Downstream	H		50		30	30	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	1040	
Dumped Snow Melt	J																								
Control Snow	K																								
Schenectady, NY																									
Upstream	L		150		160	160	5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		
Far Upstream	M		165		50	40	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		
Downstream	N				155	145	5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	590	
Dumped Snow Melt	P																								
Control Snow	Q																								

Lower limit of detection 2 µg/liter Analysis method FLAMELESS ATOMIC ABSORPTION

Nitrate nitrogen, micrograms per liter

SAMPLING SITES	Code	Date 12/5	12/26	1/9	1/22	1/30 2/1	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/28	9/17	10/4	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A																						
Dumped Snow Melt	B																						
Control Snow	C																						
Upstream	D																						
Downstream	E				7	7	7	5	4	<4								2	5	<2		3	
Lowell, MA																							
Upstream	G																						
Downstream	H				7	7	7	5	4	<4								<2	<2	<2	<2	<2	
Dumped Snow Melt	J																			20	12		
Control Snow	K																				<2		
Schenectady, NY																							
Upstream	L																						
Far Upstream	M																						
Downstream	N				7	7	7	5	4	<4								<2	-	<2		4	
Dumped Snow Melt	P																			35			
Control Snow	Q																						

Lower limit of detection 2 MICROGRAMS/L Analysis method "STANDARD METHODS" 13TH ED.

TABLE A–9 SUMMARY OF SAMPLING ANALYSES

Total Solids, Milligrams per Liter

SAMPLING SITES	Code	Date	12/17	12/27	1/4	1/9	1/22	1/30	2/1	2/4	2/26	3/12	3/25	4/8	4/19	5/7	6/5	7/2	8/28	9/17	10/4	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																											
Dump Site	A			226	301	238	275		391	279	287	288	214	228		166	222	312	192	322	299	223	182	227		280
Dumped Snow Melt	B																										
Control Snow	C																										
Upstream	D			95	38	92	246	302	217	210	259	218	220		182	329	291	197	226	253	235	266	236		345
Downstream	E			228	245	252	247	282	279	263	279		326		172	216	956	215	267	276	206	320	249		253
Lowell, MA																											
Upstream	G			134	166		136	146	149	91	119	115	116		118	118	205	149	141	170	125	117	167	113	107
Downstream	H			141	160	39	169	149	158	94	108	112	124		124	109	198	166	173	175	133	119	147	105	107
Dumped Snow Melt	J			553	643																		2750	1295	
Control Snow	K						6																91	7	
Schenectady NY																											
Upstream	L				180	192	168	138	177	155	128	196	196		128	116	584	192	232	201	138		165		193
Far Upstream	M			198	179	167	179	179	233	133	193	102	132		129	109	312	181	174	210	165	155	152		147
Downstream	N				189	168	168	186	174	147	130	122	197		150	116	279	185	165	204	193	198	184		196
Dumped Snow Melt	P			645																			9730		
Control Snow	Q			212			693																11		

Lower limit of detection: 1 MG/L

Analysis method: EPA "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES," 1971

Dissolved Solids, Milligrams per Liter

SAMPLING SITES	Code	Date	12/17	12/27	1/4	1/9	1/22	1/30	2/1	2/4	2/26	3/12	3/25	4/8	4/19	5/7	6/5	7/2	8/28	9/17	10/4	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																											
Dump Site	A			196	310	93	255	292	288	261	270	212	200		135	86	370	191	247	253	210	175	188		231
Dumped Snow Melt	B						1197																				
Control Snow	C						< 1																				
Upstream	D			152	280	110	211	256	215	207	225	93	203		180	96	188	178	210	223	196	178	166		197
Downstream	E			205	235	271	205	258	266	243	229	192	186		170	199	250	172	204	198	126	229	85		214
Lowell, MA																											
Upstream	G			96	90	69	84	115	123	82	89	79	101		94	57	166	120	135	138	126	66	182	100	73
Downstream	H			102	149	100	118	190	193	86	91	108	79		84	54	133	162	131	129	109	66	127	96	67
Dumped Snow Melt	J			176	53																		2310	638	
Control Snow	K						25																27	92	
Schenectady NY																											
Upstream	L				192	101	120	114	168	114	112	136	130		76	70	439	168	179	159	119		82		
Far Upstream	M			124	152	89	146	116	165	109	142	78	122			69	242	178	138	155	122	90	105		
Downstream	N				209	106	159	170	152	116	93	112	123		90	73	159	184	162	161	119	87	135		
Dumped Snow Melt	P			10,200			1169																3320		
Control Snow	Q						11																18		

Lower limit of detection: 1 MG/L

Analysis method: EPA "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES," 1971

TABLE A–10 SUMMARY OF SAMPLING ANALYSES

Oil and grease, milligram per liter

SAMPLING SITES	Code	12/5	12/26 1/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/28	9/17	10/14	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A	.08	.08	.34	.26	<.05	.08	<.05															
Dumped Snow Melt	B					.59																	
Control Snow	C					Melt																	
Upstream	D	.05	.10	.28	.12	.48	.55	<.05															
Downstream	E	.14	.10	<.05	.18	.32	.08	<.05															
Lowell, MA																							
Upstream	G		<.05	<.05	.14	<.05	.06	<.05															
Downstream	H		<.05	.14	.27	<.05	.08	<.05															
Dumped Snow Melt	J		.262	.99																			
Control Snow	K		.62			.06																	
Schenectady, NY																							
Upstream	L			.33	.18	.08	.07	<.05															
Far Upstream	M		.20	.27	.30	<.05	<.05	.07															
Downstream	N			.03	<.05	.11	.14	<.05															
Dumped Snow Melt	P		.118 .39			.31																	
Control Snow	Q					<.05																	

Lower limit of detection 0.5 mg/l

Analysis method GRAVIMETRIC "STANDARD METHODS" 13TH ED. USING FREON 113 AS EXTRACTANT

Lowest value for upstream and downstream sites

Cod, milligram per liter

SAMPLING SITES	Code	12/5	12/26 1/27	1/9 1/10	1/22 1/23	1/30 2/1 2/2	2/12	2/26	3/12	3/25 3/26	4/18 4/19	5/7	6/5	7/2	8/28	9/17	10/14	11/5	12/3	12/17	1/15	2/5	2/27
Woburn, MA																							
Dump Site	A	4	6	6	10	8	7	13	13	14	15								9	14	14		6
Dumped Snow Melt	B					74																	
Control Snow	C					7	6																
Upstream	D	12	5	5	14	8	9	11	14	11	13								19	18	13		14
Downstream	E	12	6	9	15	15		11	13	13	12								18	24	13		6
Lowell, MA																							
Upstream	G		12	6	14	11	11	14	12	15	17								21	19	15	20	15
Downstream	H		11	8	15	11	12	14	11	16	19								27	14	17	19	21
Dumped Snow Melt	J			30																	>50	>50	
Control Snow	K					4															5	-	
Schenectady, NY																							
Upstream	L		9	7	10	7	7	9	7	8	9								14	-	10		8
Far Upstream	M		7	6	12	7	7	8	7	7	9								14	9	12		8
Downstream	N			9	12	7	8	8	8	7	6								12	2	14		8
Dumped Snow Melt	P					46															>50		
Control Snow	Q					1															5		

Lower limit of detection 5 (10 mg/l 3RD DILN TO AN ORDER OF MAGNITUDE)

Analysis method LOW COD METHOD GIVEN IN "METHODS FOR CHEMICAL ANALYSIS OF WATER + WASTES", 1971, EPA

TABLE A–11 SUMMARY OF SAMPLING ANALYSES

Loss on ignition, milligrams per liter

SAMPLING SITES	Date / Code		12/26	1/9	1/22	1/30 2/1		2/12	2/26	3/12	3/25 3/26	3/31 4/19	5/7	6/3	7/2	8/28	9/12	10/4	11/5	12/2	12/27	1/15	2/5	2/27							
			12/15	12/27	1/10	1/23	2/2																								
Woburn, MA																															
Dump Site	A							26	42	42	30	9	38	27	30	85	90	110	53	87	42	23		85							
Dumped Snow Melt	B																														
Control Snow	C																														
Upstream	D																														
Downstream	E					97	48	21	43	43	26	18	18	26	9	89	69	80	82	70	60	48		96							
Lowell, MA																															
Upstream	G							11	28	13	16	20	21	25	10	86	105	81	80	108	28	60	92	55							
Downstream	H					11		9	26	20	20	21	56	29		109	95	63	112	82	13	125	73	54							
Dumped Snow Melt	J																					115	90								
Control Snow	K																						65								
Schenectady, NY																															
Upstream	L								34	20	14	51	23	9		110	64	65	29	48		92		53							
Far Upstream	M							5	30	16	67	11	33	25	20	104	83	90	51	97	34	116		85							
Downstream	N					58	16	19	25	15	16	13	29	22	13	105		92	100	91	20	103		56							
Dumped Snow Melt	P																					99									
Control Snow	Q																					70									

Lower limit of detection 1 MG/L

Analysis method EPA "METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES", 1971